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January, 1941

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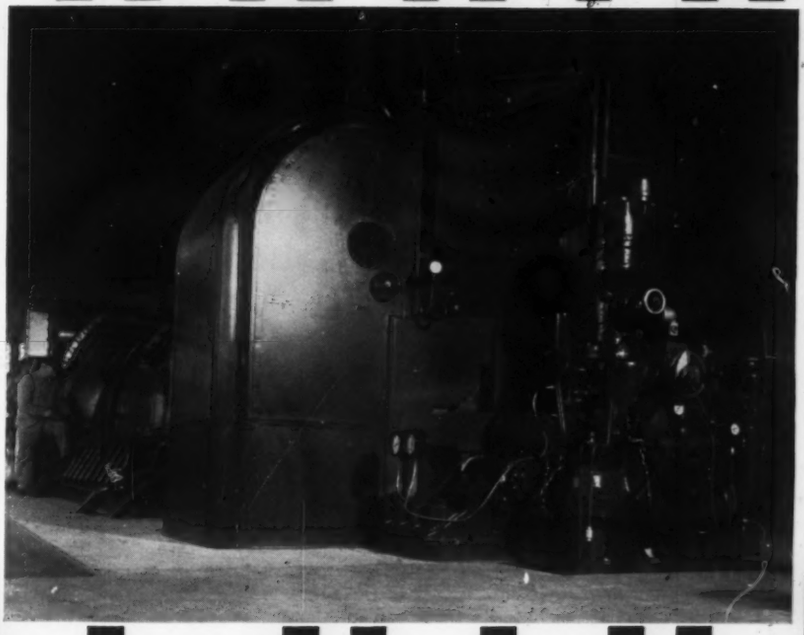
MACHINE DESIGN



In This Issue:

Selecting Special Motors in Design

When To Use Molybdenum Steels

WANT THIS KIND OF PERFORMANCE ON YOUR MACHINES?

Read These Interesting True Case Histories How Allis-Chalmers Lo-Maintenance Motors are Providing Long-Life, Low-Cost Motor Service to Industry! Find Out How They Can Give YOUR Equipment New Sales Appeal!

WHEN YOU build and sell a machine, your most important job is to see that your customer gets complete satisfaction. For that machine is your best advertisement for future orders!

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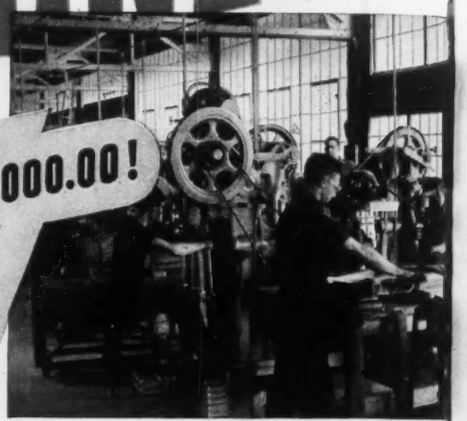
To get this kind of performance . . . and to assure yourself complete customer satisfaction — it will pay you to get the Allis-Chalmers Lo-Maintenance Motor story.

For, in Lo-Maintenance Motors you get such "full-measure" features as — distortionless, twistless stator . . . indestructible, removable rotor . . . high carbon steel frame . . . no skimping anywhere on materials or workmanship! And these are the extra-value features that your customers want . . . that will help you sell your equipment.

There's an engineer, trained in solving equipment manufacturers' problems, in the district office near you. Call him . . . today! Or write Allis-Chalmers Milwaukee, Wisconsin.



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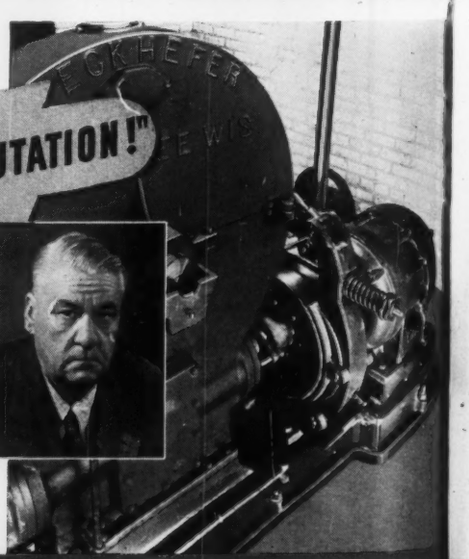

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"Allis-Chalmers Lo-Maintenance Motors help us protect our reputation as builders of elevators that won't break down"—says E. F. Kieckhefer, vice-president, A. Kieckhefer Elevator Company.

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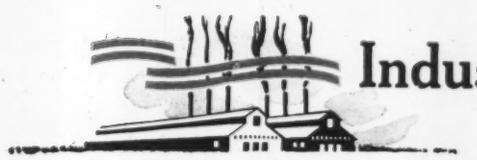

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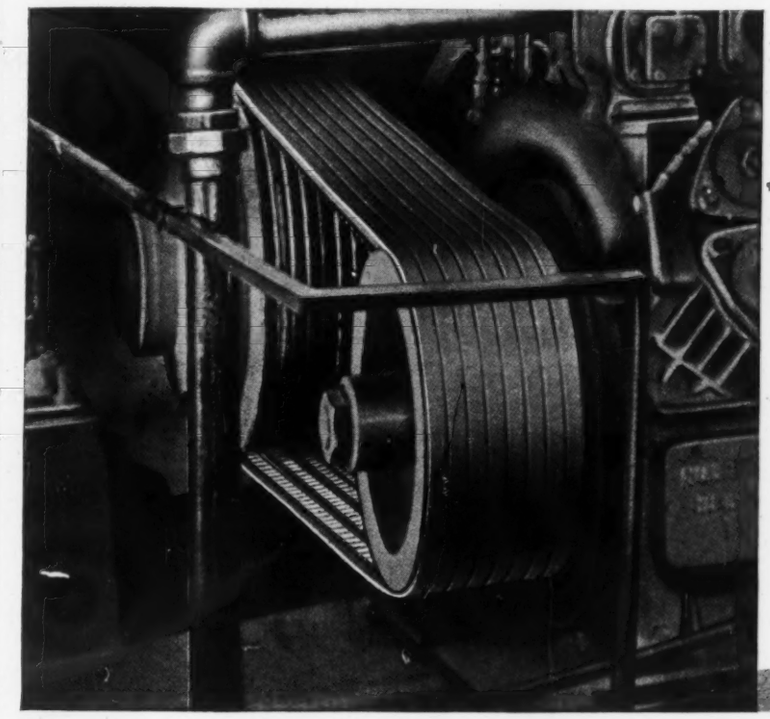
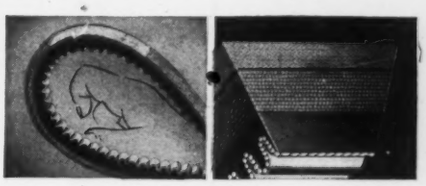


The Plus-Value DAYTON V-BELT



1 *The only V-Belt with patented built-to-bend construction—outstanding in basic design.*

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So—on big jobs or on little jobs—inside or outside—wherever and whenever your power transmission needs call for fractional or a thousand horsepower—remember there is a plus-value Dayton V-Belt Drive ready to deliver more power at less cost and save you precious time, money and machinery. And remember, also, there is a Dayton distributor as near to you as your telephone.

THE DAYTON RUBBER MFG. COMPANY
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The World's Largest Manufacturer of V-Belts

FOR A LONG PULL and A HARD PULL IT'S...

Exhaustive tests prove that Dayton V-Belts with Daytex Cord have the *extra* strength, *extra* flexibility, *extra* life and *extra* gripping power to deliver plus-power transmission under rigorous conditions at less-cost-per-month-of-service.

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1	✓ + LONGER LIFE.
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5	✓ + GRIPPING POWER.

Dayton V-BELT DRIVES *WITH DAYTEX CORD*

Topics

AN INTERESTING variation of sound measurement as an aid in design was discussed at the recent A.S.M.E. meeting by R. F. Palmer of Eastman Kodak. Bearing failures are accompanied by a change in the character of the sound and conversely, when there is a change in sound of bearings, failure is imminent. To detect incipient failures, Eastman uses a sound recorder periodically on all critical equipment. A crystal microphone is placed on the bearing or some stationary part of the machine and sound waves are picked up, amplified, and recorded. By measuring the distance between selected oscillations of the needle, the vibrations are translated into rotational speed, and the bearings running at that speed are located. Mr. Palmer believes potentialities of this method have not been fully utilized.

HAVE you ever felt, when you've seen ham and eggs or roses or cigarettes on the movie screen, you could "almost smell them?" It won't be long before this actually happens—in fact, osmic (odor) talking film was shown toward the end of the New York Fair. Two Swiss engineers are the inventors and their film had "passages" of odor lasting a few seconds each. Synchronization with scenes shown was good, though not perfect.

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DESIGNERS who have long advocated more research will derive encouragement from the General Motors decision to dedicate its two new mobile scientific caravans "to the vital task of arousing the nation to the necessity of intensifying its research activities." All over the country, highlights of the GM exhibits at the Worlds Fairs will be shown indoors and out, by the New Previews of Progress and New Parade of Progress, respectively. A GM statement urged expenditure of "ten—even one hundred times as much as now for research. . . . The hope of America, in time of emergency as in time of peace, lies in the retorts and test tubes of its research laboratories."

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PUBLIC statements by persons close to the country's defense program, urging expenditure of hundreds of millions of dollars for synthetic rubber factories added an ironic tinge to a recent Goodyear announcement. Despite this country's undoubted ability to make a complete switch to the artifical material, it should be realized that at present we are a long way from that point. Goodyear is building a plant to treble its production of Chemigum. The percentage increase is large but actually only 75 men will be employed in the new factory. It is significant, moreover, that although Chemigum can substitute for natural rubber, and may also be blended with real latex, it is now being used for mechanical parts, not for tires. Among its advantages are increased tensile strength, resistance to aging, abrasion and oils. Utilizing the same general production methods and equipment currently in use with natural rubber, it may be processed more easily than Buna.

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LAST March MACHINE DESIGN included a discussion of the Flightray, an instrument utilizing the cathode ray tube to show on its dial all the information needed by an airplane pilot. This apparent trend toward dovetailing a lot of miscellaneous information into one easily discernible piece of equipment has brought about another aeronautical instrument, the Planetest Manograph. It uses a magnetized metal tape and records (like a phonograph disk) simultaneous reports of sixteen aircraft phenomena and readings during test flights. Each test engineer has his microphone, which may be strapped to his throat without interfering with oxygen-breathing apparatus.

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USE of motion pictures to assist in teaching engineering in several universities is an interesting trend, but apparently a logical one since 40 per cent of a man's conceptional knowledge is said to be derived from sight. Several variations are in use. One consists of making a master drawing containing all phases of the complete cycle of a mechanism to be photographed. After this drawing is duplicated by offset, a second is prepared showing all parts of the machine that do not change from phase to phase, similar to the treatment of background in animated cartoons. This drawing is photographed and overprinted in black on the offset. Each phase of the motion is finally drawn in India ink on the individual prints and photographed.

MACHINE DESIGN

Selecting Special Motors

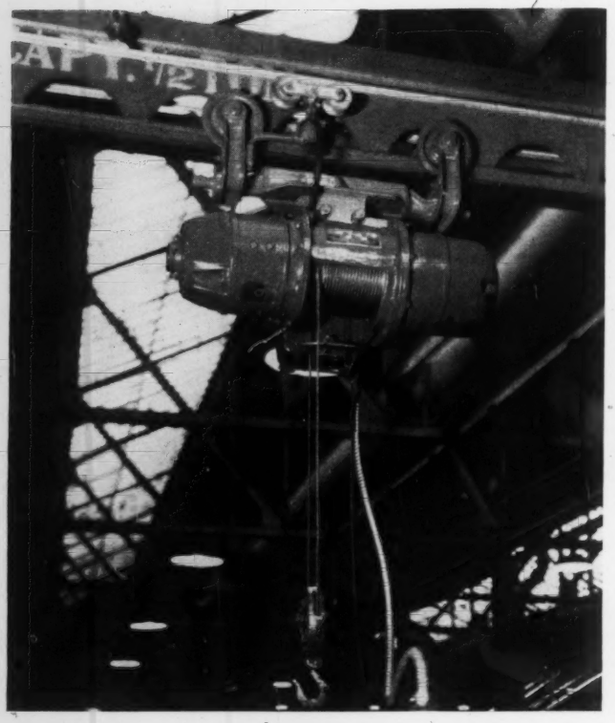
Part I—Mountings and Enclosures

By C. W. Drake
Westinghouse Electric & Mfg. Co.

MANY motors are special in that their mechanical and electrical characteristics have been modified so that they may better meet the requirements of the machines to which they are applied. Most of these motors, however, are now listed as standard or with available modifications. Having a wide variety from which to choose, the task of the machine designer is primarily to determine which mechanical arrangement and electrical characteristics best meet his needs.

In some cases no motor has exactly the right dimensions, proportions or characteristics and an entirely special motor is desired. If the results that could be obtained with such a motor justify its development or, especially, if a large number of machines are expected to be manufactured, then cus-

Fig. 1—Open motors mounted on vertical bracket bosses driving rayon twisters. Belt tension is maintained by carriage adjustment to desired position



Ffg. 2—Compact and balanced drive is provided for hoist by using flange-mounted direct-current motor

tom-made motors may be considered desirable.

In a motorized machine it is necessary to take into consideration the following factors when determining the most suitable type of motor.

1. Mechanical features, such as the method of mounting, enclosures, etc.
2. Electrical characteristics to give the best machine performance, such as starting and maximum torques, speed regulation, type of insulation, method of ventilation, and of equal importance the type of control and proper location of control stations.

MECHANICAL MODIFICATION OF MOTORS: Improved efficiency is obtained with power applied as closely as possible to the point of utilization, and this also results in a drive with the fewest parts and consequently with maximum reliability. The enclosure within the machine of belts, chains, gears, etc., is used, and the location of the motor in the most suitable position, materially simplifies the work of the designer in producing a pleasing and economical unit.

METHODS OF MOTOR MOUNTING: Among the so-called special methods of motor mounting, the flange type is the most common and has numerous modifications of mounting. One is known as type *A*, with flange located at the point where the bracket joins the motor frame, and another as type *B* with the flange on the bracket extension near the end of the bearing housing. Type *A* permits more of the motor to extend inside the machine housing, making a shorter outside extension, whereas type *B* is more commonly used when the machine drive is just within the housing.

Accessibility for assembly, maintenance of the motor and mechanical drive often have a bearing on the type of mounting used. On many smaller sizes of motors, lugs or bosses on the brackets are machined and tapped for bolts extending from the inside of the machine housing. This method of mounting requires a small diameter bolt circle with a small opening in the housing which is of advantage in close quarters. Bracket boss mounting is extensively used on motors for silk and rayon twisters or spinners where the motors are mounted vertically and suspended from a carriage on ways so that by means of a spring or lever system automatic belt tension adjustment is maintained. Such a drive is shown in *Fig.* 1. Most vertical type motors are, however, used for coupled service such as centrifugal pumps, and are commonly supplied with ring bases much the same as the type *B* flange on a horizontal motor. The use of flange-mounted motors, besides contributing to a pleasing design of machine, materially reduces the dimensions of the foundation plan. Elimination of motor bedplates and pedestals simplifies the handling of material and maintenance of shop cleanliness.

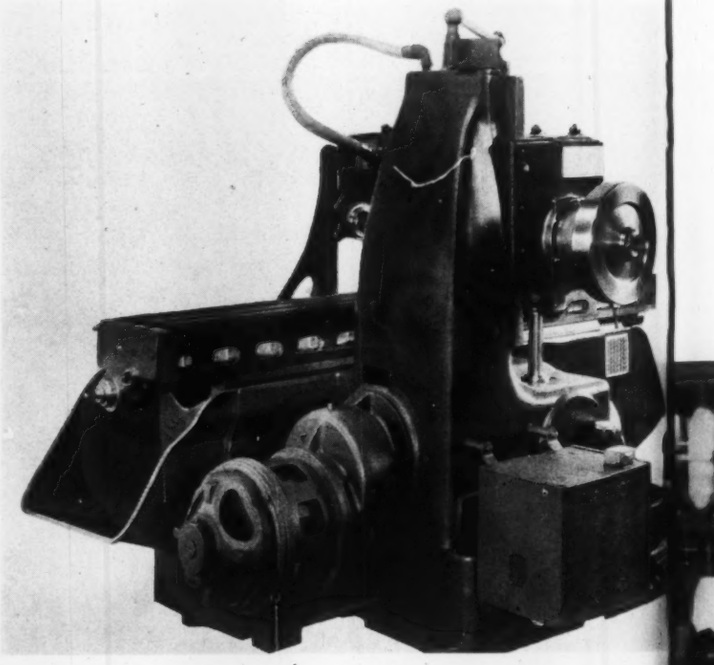


Fig. 3—Economical design and reduced cost are achieved through flange-mounted gearmotor to provide low-speed output with the performance of a high-speed motor

QUESTIONS of drive selection often involve a decision as to whether standard or special motors should be used. The latter have advantages in that the best mechanical and electrical characteristics may be combined for a particular type of machine. Also, simplification in design often results. The alternative of using a standard motor, however, with its lower cost and greater availability must be considered. This article is one of a series planned to discuss the various factors involved

Besides the foregoing arrangement of complete motors there are occasions where motor stators and rotors only, motors with one bracket only, and various other partial assemblies can be used to advantage. In Fig. 2, flange-mounted motors simplify the hoist design and provide a compact efficient unit.

MOTOR SPEEDS VERSUS MACHINE SPEEDS: For the best performance and economical cost, small or medium size motors, especially alternating current, should run at comparatively high speeds, as for instance 1750 or 1150 revolutions per minute on 60 cycles. Lower speed motors are of course available, but in most cases where machine driveshaft speeds are 900 revolutions per minute or below it will be found more economical to use gearmotors. The advantages increase rapidly as the machine speed decreases, and if a 5-horsepower motor were used for direct drive at 600 revolutions per minute the comparison of a 5-horsepower gearmotor with it would be as follows:

Type of Drive	Efficiency ½ Load %	Efficiency Full Load %	Power Factor ½ Load %	Power Factor Full Load %	Starting Torque† %	Approximate Price
Gearmotor* ..	81	82	81	90	150	$151
Slow speed motor	79	81	46	66	115	194
Gearmotor advantage ..	2	1	35	24	35	43

*Efficiency is based on entire unit including gear loss of 2 per cent.
†Starting torque is based on percentage of full load torque.

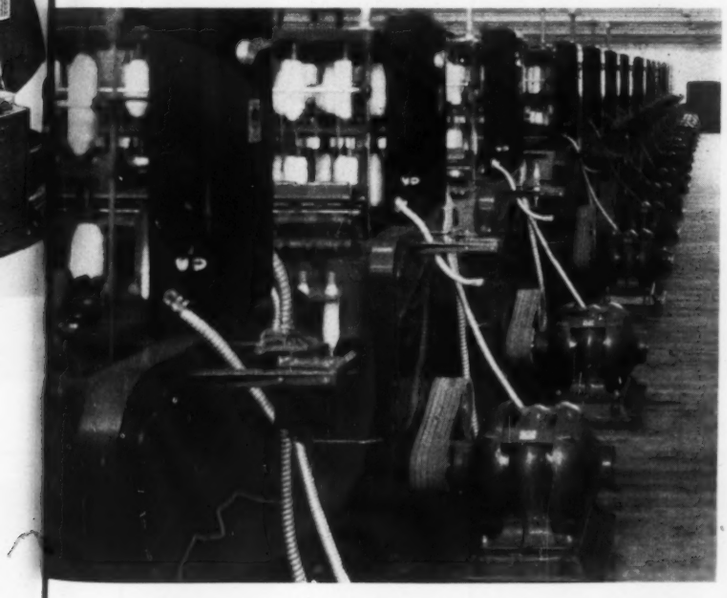


Fig. 4—Open construction and special coil finish provide passage for cotton lint through this motor

It is evident from the table that even including the gear loss of 2 per cent the gearmotor at 600 revolutions per minute has the advantage from all points of view. *Fig.* 3 illustrates the application of a 5-horsepower 600 revolution per minute squirrel cage gearmotor with flange mounting.

For many drives, low speeds such as 20 or 30 revolutions per minute are required and the self-contained gearmotors provide a compact and reliable method of gearing down to the desired speed. When mechanical brakes are required they are installed on the extension of the motor shaft and due to the high speed of the motor, usually 1750 revolutions per minute brakes are of comparatively small size.

TYPES OF ENCLOSURES OR VENTILATION: For the majority of applications the standard open induction motor is sufficiently protected, while on direct-current motors, covers over the commutator may be desirable for mechanical protection. Often it is found, however, that the increased cost for some extra protection is fully justified by the reduced maintenance and the increased reliability of operation.

Dust May Restrict Ventilation

Some materials, like rock or cement dust, sawdust and cotton lint, are not injurious to the windings, but unless frequently blown out reduce the motor ventilation and may cause excessively high temperatures. The motors shown in *Fig.* 4 are especially designed with wide clearances and polished insulation to allow free passage of the lint or to make it readily blown out if some should collect. Other materials, especially metal dust from grinders or machine tools, various chemicals, etc., are injurious and motor maintenance is reduced by excluding them from the motors.

SPLASHPROOF MOTORS: Such enclosures as the name implies are primarily for use in wet places and where a hose may be used for washing up. They are extensively employed in the pulp and paper mills, textile finishing mills, chemical plants, packing houses, on centrifugal pumps, etc. Although being protected from direct action of water, ventilating air still passes over and around the motor winding, and consequently if this air contains a large amount of dust or foreign material its presence or collection in the motor would be unnoticed until the motors were opened for inspection or some difficulty due to overheating was encountered. Splashproof enclosures are employed on the

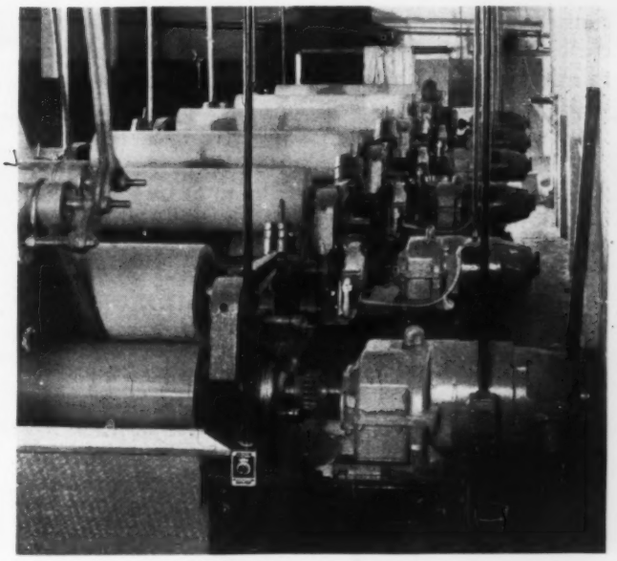


Fig. 5—Double-reduction gearmotors coupled to rolls and direct-current variable-voltage motors have splashproof enclosures for protection against water and other liquids from textile washing range

double-reduction gearmotor drives in *Fig.* 5.

TOTALLY ENCLOSED NONVENTILATED MOTORS: Complete enclosure without ventilation makes an ideal solution from the standpoint of simplicity of motor design and protection, but unfortunately is economical only in motors of small horsepower rating when desired for continuous duty. In the textile industry, totally enclosed loom motors have been standard for many years, and on machine tools totally enclosed motors both alternating current and direct current are widely used for pumps and auxiliary drives. As a rule, for continuous operation it is more economical on motors of 3 horsepower and above to use fancooled construction or some other method of ventilation.

When motors are used only intermittently, for in-

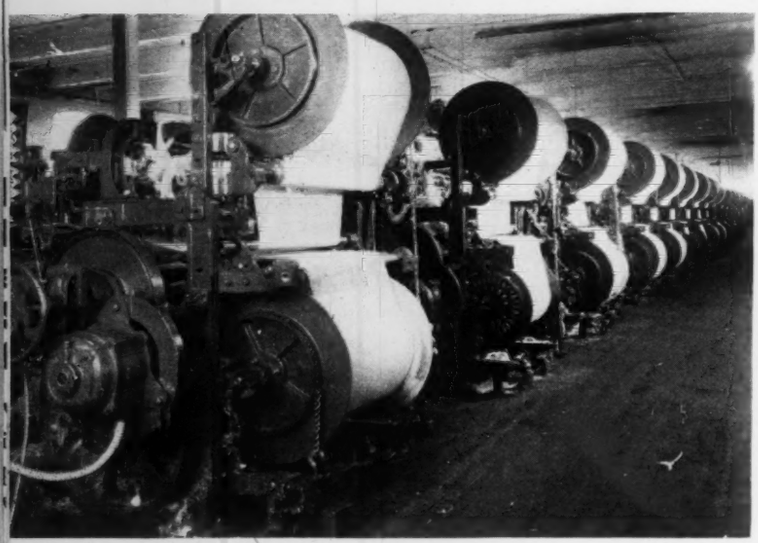


Fig. 6—Totally enclosed motor uses three-point mounting. Motor has a tapered shaft for pinion mounting

stance for roll adjustments, valve operation, tire vulcanizers and similar applications, the use of totally enclosed motors of nearly any size is economical, since in most cases the size of the motor is chosen on the basis of the torque it will develop rather than from the standpoint of heating. The actual cycle duty must be considered in each case, but when the operating time is a small percentage of the total time the question of ventilation or heating is of comparatively little importance. A totally enclosed motor application on a loom is illustrated in *Fig.* 6.

TOTALLY ENCLOSED PIPE VENTILATED MOTORS: Although forced ventilation is one of the most satisfactory methods of cooling, the complications and expense of blowers and ducts in general limit its use to the larger motors. Except in hazardous locations, the air from the motors may be discharged into the room, but in hazardous locations such as grain elevators, oil refineries, etc., return ducts are required, *Fig.* 7. Direct-current motors operating on variable voltage, as for instance on paper machines, super-calenders, etc., may operate at low speeds—perhaps 10 per cent of maximum continuous—and forced ventilation permits operation at these low speeds with the same torque as at maximum speed.

The amount of air required by a motor to maintain the same temperature enclosed as when open with normal ventilation is usually estimated at 125 to 150 cubic feet per minute per kilowatt loss. The kilowatt loss of a motor is readily estimated from the full load input and the percentage efficiency. The air pressure required at the motor bracket varies somewhat with the horsepower rating and type of motor construction but averages from 1 inch to 2 inch water gage to which must be added the resistance of the piping to obtain the pressure required at the blower.

TOTALLY ENCLOSED FANCOOLED MOTORS: The high maintenance required for open motors and the mechanical difficulties involved in the installation of pipe-ventilated motors in the automotive and similar industries was largely responsible for the development of the fancooled construction which now enables machines to be individually driven with fancooled motors as readily as with the open types. Also, due to improved methods of cooling, the same frame sizes (mounting dimensions) are used in nearly all cases for a given horsepower and speed rating for both the

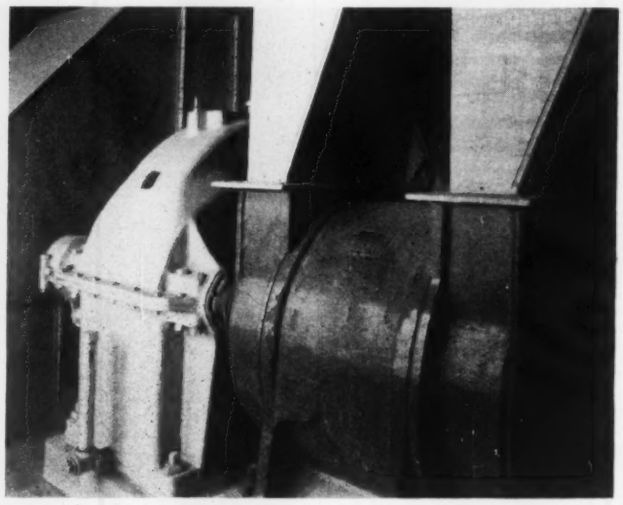


Fig. 7—These 175-horsepower synchronous motors are totally enclosed, pipe ventilated, for hazardous locations

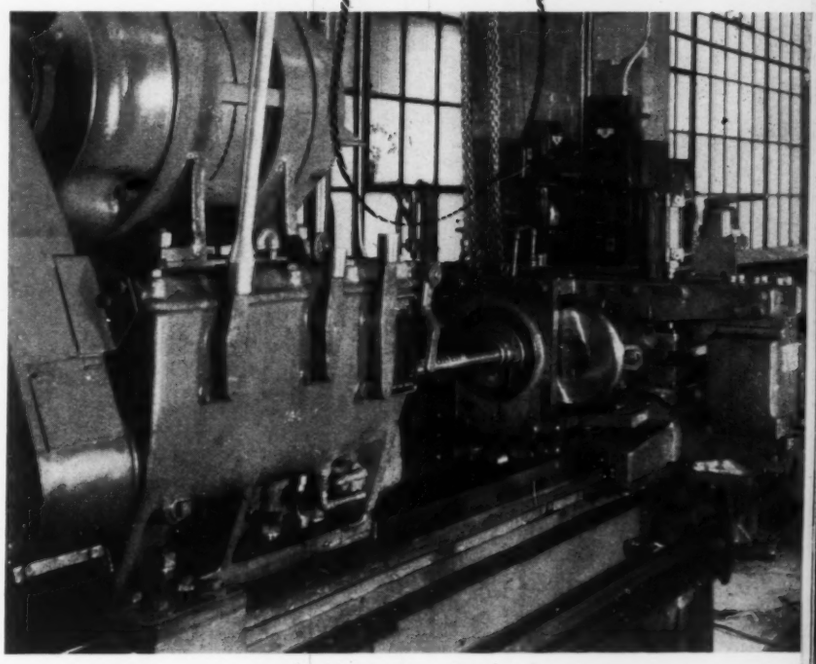
open and enclosed designs. Although the mechanical details vary considerably with various types and sizes of motors, the fundamentals are the same; that is, the motor windings are completely enclosed and the internal air circulated by the rotor conducts the heat to the outer frame and bracket where it is carried away by the external air which is blown over it by the fan.

Besides these major classifications there are many other types of motor assemblies such as the shell type for high-speed woodworking and metalworking tools, separate stators and rotors, and one of the most recent developments is the close-coupled centrifugal pump in which the pump hoisting is mounted on a special motor bracket and the pump impeller on the motor shaft. This arrangement makes a compact assembly from the standpoint of installation and piping and is being used extensively.

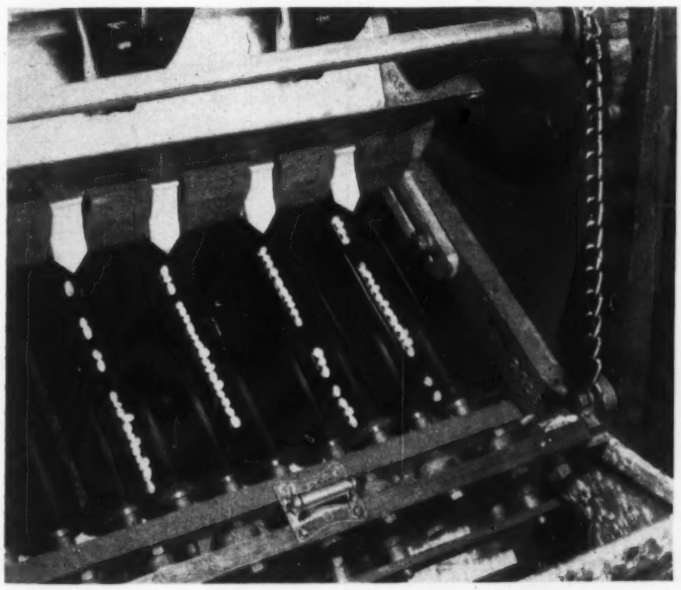
Scanning the Field FOR IDEAS

Metal spinning combined with rolling to produce a new method of fabricating tubular sections has been perfected in a new machine developed by Steel and Tubes Division, Republic Steel. With this machine, tapered or varying diameter tubes are fabricated to any reduced diameter required, ranging in cross sectional area from the original to limits determined by the characteristics of the material being worked. In this way, structural members with high strength-weight ratios may be produced economically.

Wall thickness, in addition to diameter, is controlled by proper combinations of radii on the spinning wheels, rate of travel of the carriage on which these wheels are mounted and hydraulic pressure on the floating headstock either stretching or bucking the tube being tapered. The spinning wheels are complementary in action through gearing and are positioned by a roller following a template. This template is backed by the carriage in such a way that the stresses on it are compression, there being no flexing forces due to the backup.

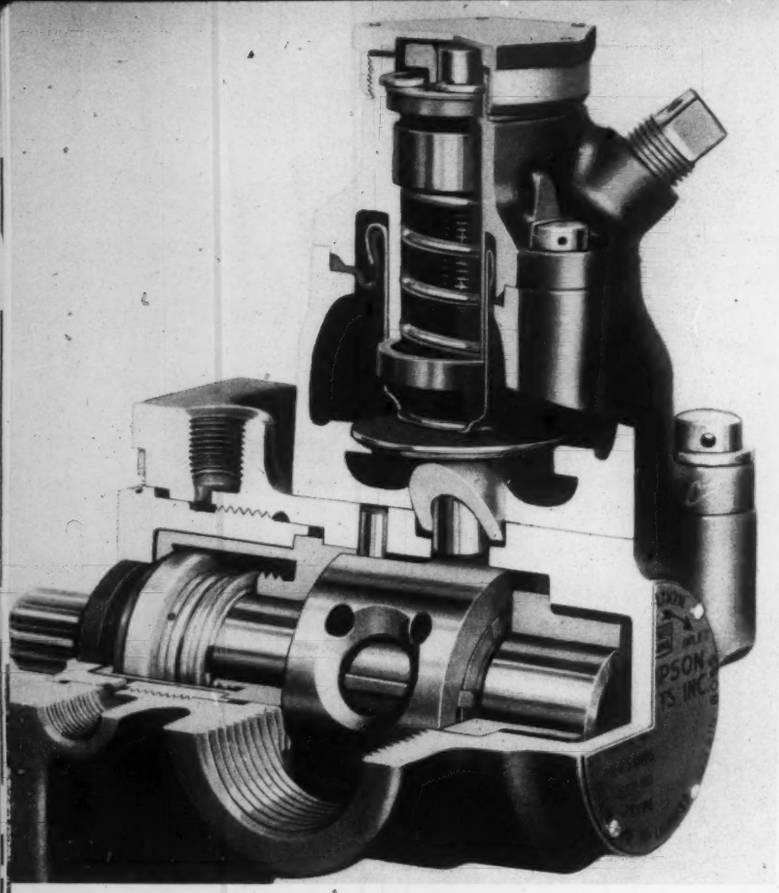


Machine functions are hydraulic with the exception of the headstock spindle. That is driven direct by a 50-horsepower motor through a gear unit. Carriage feed and headstock movement are controlled by separate hydraulic systems.

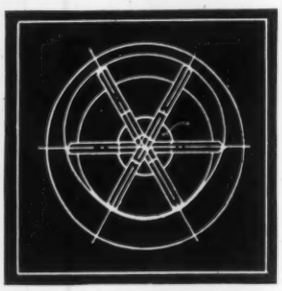


Mechanical sorting and grading have done much to provide economical processing and higher quality product. Such is the case for the machine illustrated at the left. Beans are spread over whirling pairs of rubber rolls. As the beans move downward, the inferior beans being wrinkled and smaller are caught between the rolls and separated by passing through to a waste bin.

Utilizing a special rubber developed by Goodrich which is smooth on the surface to allow good beans to slip over it, yet soft enough to seize any wizened "culls", the rolls are efficient and have a relatively long life.



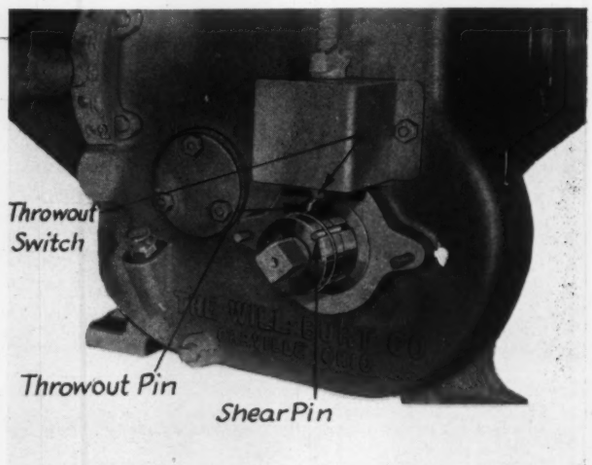
Non-pulsating delivery is provided in the rotary displacement pump shown at left for aircraft fuel. Three blades or vanes extending through the rotor form the pumping chambers in the bore of a specially shaped liner. Designed by Thompson Products, Inc., the bore consists of arcs and spiral arcs so positioned that there is a positive cam action on the blade elements. The spirals give the blades a shuttling motion that is without shock at either end of travel. High suction lift and rapid build-up of pressure at low crank speeds are provided by the seal between liner and rotor. Action of rotor blades on the liner bore is shown in the schematic diagram.



Relief valve is a balanced diaphragm of molded synthetic rubber. It provides a bypass for the fuel to give a constant discharge pressure. Shaft seal utilizes a hardened ring divorced from the splined drive shaft and guided by the rotor journals.

Adjustable pitch propeller designs have reached a high degree of perfection in airplanes and hydraulic turbines using oil pressure systems to adjust the pitch. In the turbine runner illustrated below, however, the blades move automatically with changes in flow as well as with changes of speed and head, without the use of oil lines or extra governors. Control is entirely by the turbine water supply. The blades are pivoted considerably ahead of their centers of area as well as ahead of their centers of pressure in such a way that they tend to adjust themselves to the most efficient angle for each condition of operation.

The blades being pivoted slightly upstream have small moments about the blade axis and relatively small forces on the internal mechanism. Runaway overspeeds are prevented by closing of blades. Also, to reduce end thrusts, the blades open on starting and shutdown. Design and development of this unit are discussed by R. V. Terry in a recent A.S.M.E. paper.



Re-usable shear pin lies in a slot parallel to the drive shaft as shown above instead of through a hole in shaft coupling. Thus with this method it is easier to assemble the shear unit, designed by the Will-Burt Co. In addition, one pin may be used again several times after shearing by moving it along the coupling.

To protect other operating parts of the unit as well as the driven shaft, a plunger on a throwout switch is engaged when the pin shears. This switch is shown immediately above the shear pin. Any signalling device required may be connected to this switch to indicate when the unit has been disconnected by an overload.

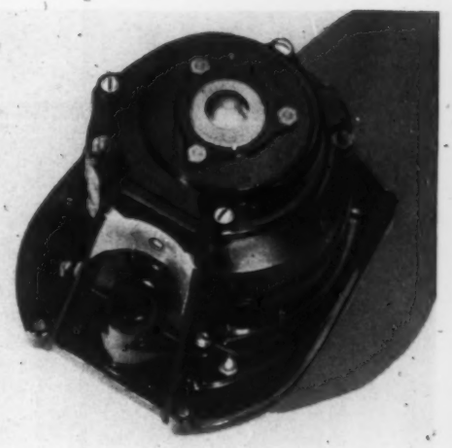


Fig. 7—Self-tapping screws promote economy and facility of assembly in motor and rotor housing of vacuum cleaner

Part II—Special Screws and Washers

Machine Fastenings in Design

By Kenneth D. Moslander

VIBRATION resistant properties of self-tapping screws have perhaps not been emphasized to the extent they deserve. Ordinarily specified as a means of attaining economy in assembly, these screws have intimate thread contact which is most efficient in resisting all common loosening tendencies. In being driven by any suitable hand or power screw driver into a hole of proper size, the female thread is formed by and around the screw. Exact conformation of the threads produces a maximum bearing surface which is highly efficient in preventing fastening failure under conditions of severe vibration.

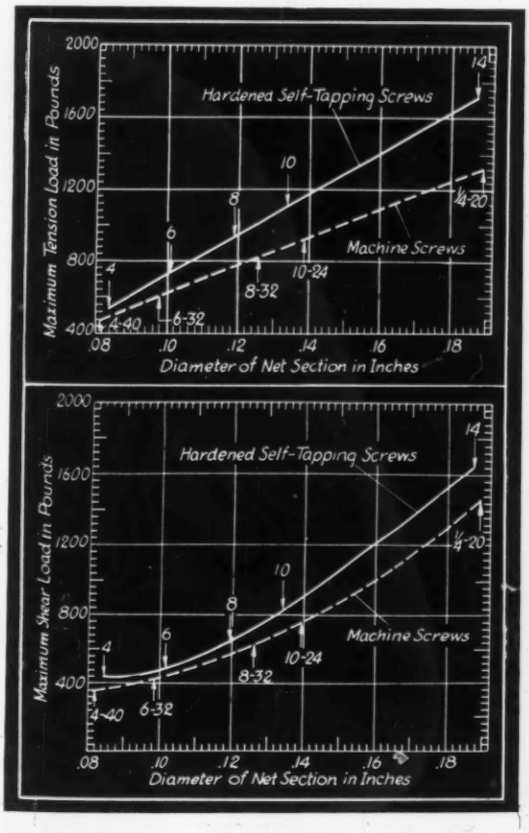


Fig. 8—Curves provide a comparison between the tensile and shear strengths of self-tapping and V-threaded machine screws

As a result of the narrower thread lands with which the screws are formed they are ideal for use in plastic materials. In such applications no tapping or threaded inserts are required. The width of the screw thread root results in a thread in the plastic part which is much stronger than the conventional V-thread in this material.

In *Fig.* 7 may be seen a number of these screws as used in the assembly of the Hoover vacuum cleaner. Other uses include the fastening of light-gage sheet metal from .015-inch thickness up, as well as fastenings to aluminum, die castings, etc. Tensile and shear properties of the screws as compared with standard machine screws of the same nominal size are shown in *Fig.* 8.

A second type of self-threading screw fastening is illustrated in *Fig.* 9 in a conveyor table assembly. These screws in this case are provided with a spring-action longitudinal slot which induces the threaded end of the screw to act as a tap while being driven home. Thus a female thread is produced which approximates a Class 4 fit with the screw with consequent high resistance to vibration. Flat head screws incorporating this thread cutting feature have found extensive use in the aircraft industries for fastening aluminum and dural sheets.

Drive screws which also do not require a tapped hole for installation are used for permanent fastenings to iron, brass, aluminum, plastics, etc. They function in a manner similar to the self-tapping screw except that they are driven with a hammer. The unthreaded portion or pilot at the tip holds the screw in place before it is driven in and also guides it so that it will go in straight. Since the diameter of the pilot is somewhat larger than the root diameter and smaller than the outside diameter of the screw, the material displaced by the thread flows over the pilot, anchoring the screw at the bottom. Holes for receiving these drive screws should be made to a diameter substantially equal to the diameter of the screw pilot. The screws should not be used in work which is much

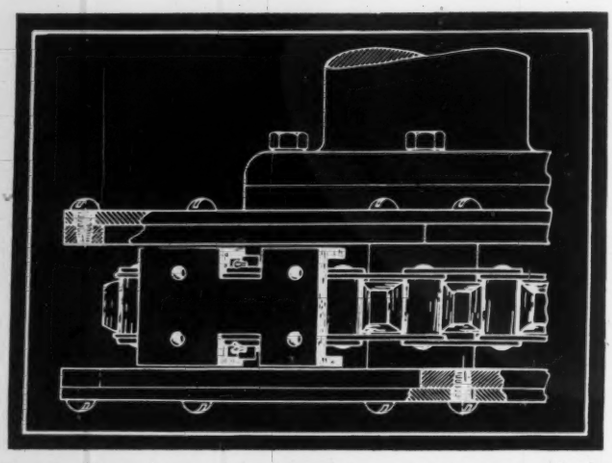


Fig. 9—Slotted type of self-tapping screws are used as the fastening means in this conveyor table assembly

thinner than the outside body diameter of the screw itself. Comparisons of the tensile and shear properties of drive screws and machine screws of various diameters are shown in *Fig.* 10.

In approaching the subject of standard bolts and nuts no attempt will be made to discuss the various styles of these fastenings such as stove, elevator, carriage, machine bolts, etc. It is presumed that the designer is familiar with these types or has information regarding them readily available in handbooks or catalogs.

Appreciable variations of tensile and shear strength of low carbon steel machine screws and bolts result from the several different processes of forming and threading. Five methods in use for forming small bolts and screws are listed in TABLE I. The ultimate tensile stress for each of these is based on tests of ½-inch, 13-thread bolts. Values given are based on the area at the root of the threads. Some specifications call for such data to be based on the area at the mean diameter which is that of the average area between the area at the root and at the pitch diameter of the thread.

In the extruded bolt, that portion of the shank which is to be threaded is reduced by cold working to the pitch diameter of the thread. In the double-extruded type, stock somewhat larger in diameter than the nominal size of the bolt is first extruded to size; the portion to be threaded is then reduced to pitch diameter.

TABLE I

Bolt Strength

Based on ½-inch, 13 thread bolts

Forming and Threading	Tensile Strength psi.
Hot headed; cut thread	72,000
Cold headed; cut thread	78,000
Cold headed; thread rolled on P. D. stock	84,000
Cold headed; extruded; rolled thread	92,000
Cold headed; double extruded; rolled thread	98,000

Increased tensile strength resulting from the cold working in these processes is to a considerable extent lost if the parts are annealed or normalized. Shear strength is, of course, somewhat reduced by cold working. In applications necessitating maximum shear as well as maximum tensile strength higher carbon or alloy steel bolts should be specified.

Applications of alloy steel bolts are confined largely to special strength, corrosion or heat resistant requirements. In heat treating these fastenings separate consideration should be given the different sizes. Threads serve as cooling fins in quenching with the result that, in the smaller sizes, excessive brittleness may result which will not be evident from the tensile strength. Impact tests or a series of brinell readings across a section through the threads should indicate the proper heat treatment. In low temperature service the draw temperature should increase as the bolt diameter decreases.

In high temperature service creep strength of the fastening becomes predominantly important. For service temperatures up to 850 degrees Fahr. S. A. E. 4140 chromium-molybdenum steel drawn to 1200 degrees Fahr. will serve satisfactorily. For higher temperatures (up to 1100 degrees) a chromium-molybdenum-vanadium steel is better used. At a nominal sacrifice of physical properties at ordinary temperatures, higher creep strength is obtained with this steel by normalizing or air quenching. The draw should be at least 100 degrees Fahr. higher than the service temperature. This conclusion is in line with other work which in-

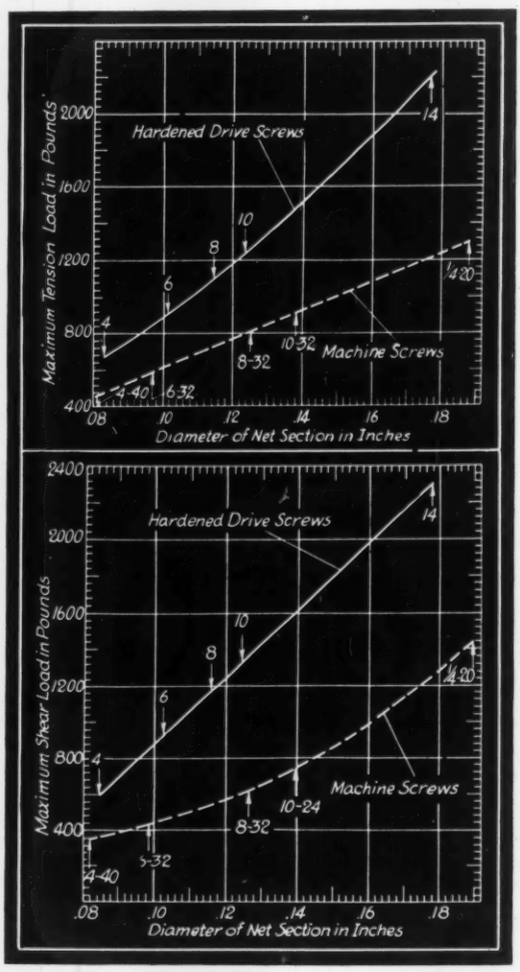


Fig. 10—Comparison between the tensile and shear strengths of drive screws and machine screws is provided by these curves

Fig. 11—Below—Positive locking is attained with these washers by means of their biting grip on the screw head

dicates that the grain size should be proportional to the service temperature for maximum creep strength. The aforementioned steel exhibits properties, along with certain other vanadium alloys, of hardening slightly upon drawing.

Values of the elastic deformation of alloy steel bolts or studs of various sizes as a result of the stress applied by tightening are given in TABLE II. These figures indicate the maximum limit of load relaxation under

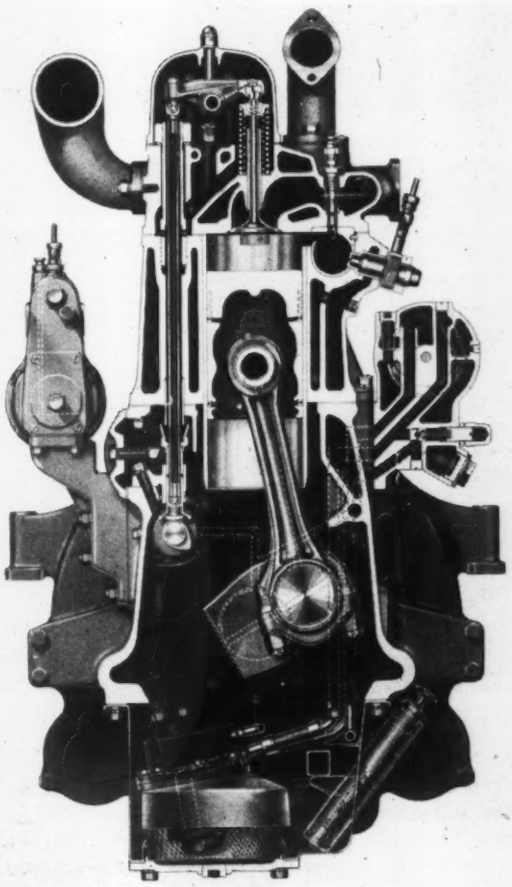


Fig. 12—Internal combustion engine utilizes many spring washers to insure permanent tightness of the assembly under severe vibration

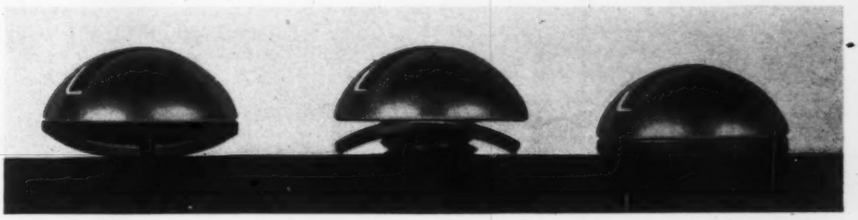


Fig. 13—Arched type spring washers maintain high tension stress in screws introducing increased thread friction for positive locking

creep conditions before looseness develops.

Several different types of lock washers are commercially available for use with standard screw fastenings to insure against the development of looseness as a result of vibration or bolt stretch. One of these, which owes its locking effect to a biting grip between the nut or screw head and the work, is shown in *Fig.* 11. Under conditions where vibration is experienced the teeth of the washer bite more deeply into both the nut and the work. Sufficient spring action is built into the washer to insure that this increased bite does not result in looseness of the assembly. Machine parts not subject to vibration in a rotative direction relative to the screw fastening provides the broadest application of this locking effect of the screw or nut to the work.

Outstanding among the many applications of these washers is in the aircraft industry and others where it is highly desirable that the screw heads be flush with the surface of the held parts; conical washers of this type are available for such service for use with flat head screws.

For use with small head screws and S. A. E. nuts, these washers are obtainable with internal teeth. In equipment assembled for consumer use such as refrigerators and automobiles, this type provides the additional advantage of not offering projections to snag clothing or upholstery.

Washer Increases Thread Friction

A second type of auxiliary locking device, the helical spring washer, provides a vibration resistant grip between the screw and nut or tapped hole by maintaining a high friction load on the engaged threads by means of sustained tension in the bolt. This tension is maintained even though clearance develops between the nut and the surface of the work as a result of bolt stretch, nut expansion, rust, etc.

Utilization of the engaged thread surface to obtain

(*Concluded on Page* 110)

TABLE II

Tightening Stresses in Bolts

Size of Alloy Steel Bolt, in Stud	Average Stress Applied Manually Lbs. per Sq. Inch	Approximate Torque to Obtain Stress Ft. Lbs.	Elongation in Inches, per Inch of Effective Length
¾	52,000	175	.00173
⅞	48,000	255	.00160
1	45,000	370	.00150
1⅛	42,500	500	.00142
1¼	40,000	665	.00133
1⅜	38,000	860	.00127
1½	36,500	975	.00122
1⅝	35,000	1285	.00117
1¾	34,000	1700	.00113
1⅞	33,000	2200	.00110
2	32,000	2350	.00107

New Hair Dryer Is Silent Salesman

By Edwin W. Vose
The Nestle-LeMur Co.

IMPORTANCE of co-ordinating mechanical design and modern styling cannot be overemphasized in the development of machines and equipment for customer use or service. Ample evidence of the attention given these considerations is provided by the advanced design of this hair dryer which incorporates many novel features.

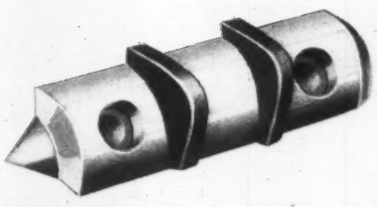
As this dryer is of the so-called pressure type, an air compressor with a capacity of at least 50 cubic feet per minute at a pressure of not less than 12 inches of water was needed. Permanently quiet operation is obtained by the development of a blower as illustrated in *Fig.* 2 of conical hub design. Die-cast of aluminum and carefully balanced, this fan produces the desired volume and pressure.

Recesses are provided in the compressor casing

(*Concluded on Page* 104)

Fig. 1—Top—Hair dryer incorporates advanced styling with many new operating features. Fig. 2—Above—Conical air blower provides quiet, vibrationless operation. Motor brush recesses are easily accessible. Fig. 3—Left—Exhaust air vents are in top of helmet. Heater coils supplement motor to provide warm air for drying purposes

Fig. 1—A wide variety of forms of cemented carbide inserts are available, in hardness next to diamond. Fig. 2—Left, below—Interesting possibilities are indicated by this camshaft with inserts brazed in



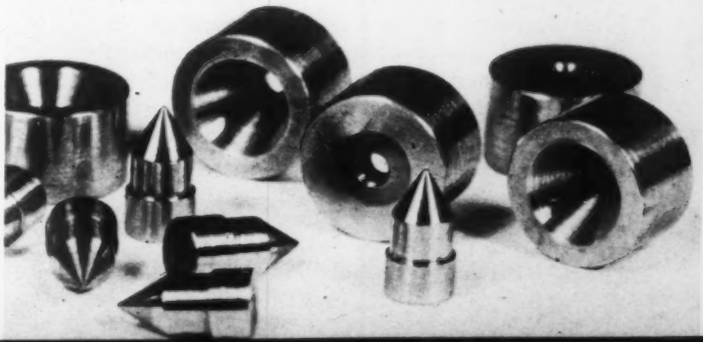
Lower Cost Adds Value to Carbide Inserts

By George Z. Griswold

WHILE extreme wear resistance has always been the chief asset of cemented carbides when used as machine parts, recent developments have emphasized their importance to designers. Drastic price reductions, particularly on standard shapes, now permit real economy in use of these materials, principally as inserts. Research on corrosion resistance has yielded fresh information to aid in expanding their application.

These inserts are a phase of the subject of hard-facing, discussed last month in M. D., and are made mainly from the carbides of tungsten or titanium with an auxiliary bonding material, commonly cobalt. Further addition of tantalum carbide will increase hardness and wear resistance without loss of heat resistance or strength, by imparting a peculiar self-lubricating characteristic. An idea of the wide variety of forms of these inserts may be gained from *Fig.* 1. They range in hardness up to 91 Rockwell C, are perfectly dense and free from porosity, and have a "non-galling" surface when rubbed.

Fig. 3 — Below — "Slow-up" valves in upper picture have stems of carbide-tipped cones and fit into carbide rings. Valves and cones in other picture withstand high pressure from abrasive liquids



Inserts Brazed in Machine Part

Commonest method of application is to braze the carbide inserts (which are molded, like other powder metal parts) in the machine part at the point of wear, and then to grind the insert to its final dimensions. On small parts, however, it is possible to make the entire piece of sintered carbide at less cost than brazing on a separate piece.

Although sintered carbides are frequently termed corrosion resistant they are not absolutely so, as brought out in a recent test. It was felt that expanding applications made necessary a knowledge of the

resistance of the inserts to hot air, acids, alkalies and sea water. Up to 100 degrees Cent. the cemented carbides are stable in hot humid air. At higher temperatures slow oxidation sets in but the resistance against oxidation increases with the titanium carbide content. The tungsten and titanium carbides can be used up to 600 degrees Cent., while borides and chromium carbide are resistant to hot air up to 800 degrees Fahr. A slight brownish discoloration of the surface results from combined attack of air and

Fig. 4—Textile guide has carbide insert which lessens abrasion on threads because guide does not cause snagging

sea water, but the effect is so limited that the carbides for all practical purposes can be considered as sea water-resistant.

Carbide materials without an auxiliary metal are very resistant at room temperature and at boiling range against hydrochloric, hydrofluoric and sulphuric acid. With auxiliary metal they resist sulphuric and hydrofluoric acid at room temperature but at boiling temperature the cobalt is attacked and dissolved. Bonding metal also renders the carbides not resistant to hydrochloric acid, but resistant to caustic soda.

Several results seem probable in the light of recent price reductions for cemented carbides. It may be possible—as never before—to specify standard carbide shapes for wearing points and thus to avoid the cost of making special molds for the parts. Perhaps the best way for the designer to handle doubtful cases is to present to carbide manufacturers drawings showing where wear occurs on parts, along with a request for advice as to whether or not a standard blank can be used. Price tables with sizes and shapes are also available.

Acceptable First Cost Is Set

Formerly it was pointed out that although cemented carbides cost much more than other metals used for similar purposes, the greatly increased life of the part (from five to 25 times) offset the initial cost. But now what might be called a commercially acceptable first cost has been set for carbides, and the outlay for them is not much more than that for other forms of construction.

During the present period of national emergency, moreover, it is necessary to conserve stocks of metals like tungsten, which must be imported. But high speed steel, for instance, also has tungsten as an ingredient, and a part made wholly of steel will require considerably more tungsten than a carbide insert, since in the latter the expensive tungsten is concentrated where it is needed.

One extremely important fact in connection with designing for carbide inserts is that while carbides are extremely hard, they are not equivalently high in tensile strength. Stated another way, they will withstand great compressive stresses but should not be unsupported where shear or tensile stresses are high. A combination of wear and severe shock is particularly bad. Intermittent and mild shock like that encountered on the camshaft in *Fig.* 2 will not damage inserts. Interesting possibilities representing a vastly wider field of application are indicated by this part, in which carbide inserts are brazed into a steel shaft. More examples of this type will greatly augment the usefulness of these parts.

Both Contacting Parts Should Be Tipped

Another precaution involved in applying carbide inserts is illustrated by *Fig.* 3. The extreme hardness of the insert may have abrasive effect on any machine part which touches it but is not protected. Hence contacting parts should always be similarly tipped, as are both types of valves in *Fig.* 3. The "slow-up" valves in the upper picture have stems tipped with carbide cones and fit into carbide rings in the female part of the valve. The valves and cones in the lower illustration withstand 6000 pounds pressure per square inch during the valving of tarry liquids containing abrasive sediment from the hydrogenation of

Fig. 5—Close-up of ball valve with carbide seat insert, used in machinery pumping oil containing sand and water

coal. They have been known to outlast alloy steel 100 times.

Two other representative applications of cemented carbides are shown in *Figs.* 4 and 5. The former is a textile guide with an insert which reduces wear on the guide and at the same time lessens abrasion on threads because the guide does not cause snagging. A close-up of a ball valve with a carbide seat insert is in *Fig.* 5. It is used to reduce abrasion wear in machinery pumping oil containing harmful sand and water.

Courtesy of the following companies in co-operating in the assembly of information and illustrations for this article is acknowledged: Carboloy Co. Inc. (*Figs.* 1, 2, 4 and 5); Fansteel Metallurgical Corp.; and McKenna Metals Co. (*Fig.* 3).

Fig. 1—Sheet leveler with roll guards removed. Multiple back-up roller assembly prevents the leveling rolls from deflecting under pressure

Short Length Back-up Rolls Improve Sheet Leveler

By W. D. Shields
Chief Engineer
Edward W. Voss Co.

IN THE design of a roller leveler for straightening steel sheets two fundamental requirements are present. One is that the rolls themselves must be rigid enough or be supported in such a way as to maintain their position under leveling pressure. The other is that the diameter of the rolls, in relation to the thickness of the sheets, must be small enough to work the material thoroughly, stretching it beyond its elastic limit.

Basically, a roller leveler consists of two tiers of rolls, closely-set one above the other with the upper rolls coinciding with the spaces between the lower ones. This staggered arrangement flexes the sheet being straightened up

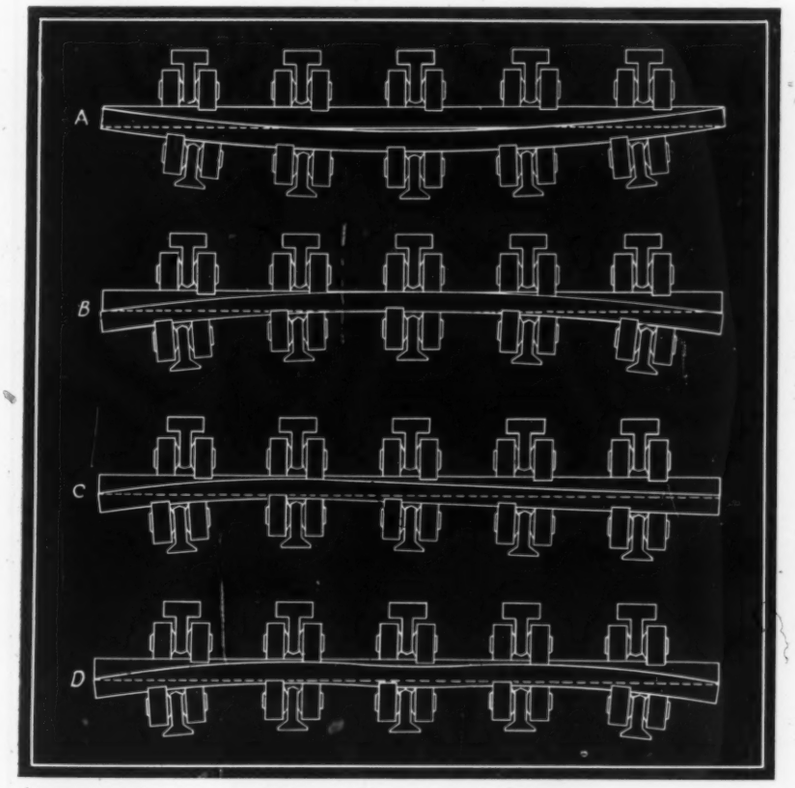


Fig. 2—Diagram showing typical back-up adjustments of the bottom leveling rolls, with roll bend exaggerated for clarity in illustrating various positions

and down over the interrupting arcs of the rolls as it passes between them. Working the sheet in this manner tends to "stretch out" the short areas resulting from previous mill operations, thereby making the sheet flatter.

When the leveler shown in *Fig.* 1 was designed, the answer to the two above requirements also gave the answer to a third, namely, that to secure a dead-flat sheet, the short areas in the sheet must receive greater plastic deformation than the other parts of the sheet.

Solution to all three requirements was a system of

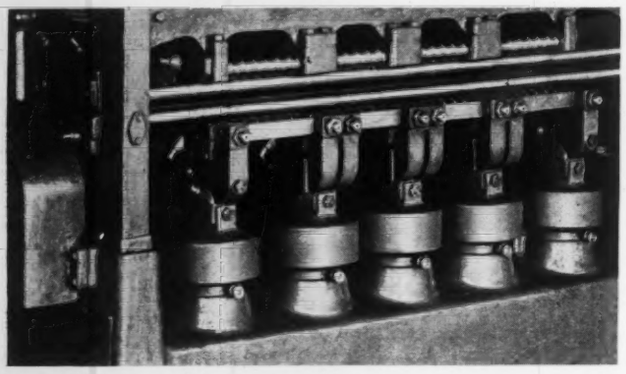


Fig. 3—Leveling rolls used on earlier design. Long back-up rolls with small diameters involved problems such as bearing design, sticking and marking of rolls

narrow back-up rollers that would absorb the load from the leveling rolls, thus keeping them in position and also permitting the use of smaller leveling rolls. These back-up rollers are capable of being adjusted to bend the leveling rolls and to bring greater pressure on any particular area of the sheet as indicated diagrammatically in *Fig.* 2.

As shown in *Fig.* 1, the back-up rollers have a diameter twice that of the leveling rolls and have a width approximately one-third their diameter. Made from a hardened and ground outer ring, each back-up roller turns on a double-row ball bearing. Pressed steel disks enclose the roller on each side and function as grease retainers for the bearings.

Back-up rollers are mounted on both sides of steel bearing supports perpendicular to the leveling rolls and at regular intervals along their length. Each bearing support constitutes a separate and easily dismantled roller group. The leveling rolls turn in the valleys between corresponding pairs of back-up rollers of each roller group.

Because both top and bottom sets of leveling rolls literally ride in a bed of back-up rollers, the first requirement—that of roll rigidity—is adequately fulfilled. Since the rolls merely transmit the leveling pressure to the supporting system, they can be considerably smaller in diameter than was previously possible, thereby satisfying the second requirement.

Power to drive the rolls is divided in a compact gear box, so that every roll is driven direct through a gearbox from the main motor. The problem of designing this gearbox resolved itself into a series of trials to get the smallest possible gear into the least possible space. The resulting gears are compact and well proportioned for driving the working or leveling rolls. Power to operate the leveler is supplied to the gearbox by a motor, operating through a variable speed range to suit the required speed of rolling for various materials being worked. Between the main driving motor and the leveler gearbox a speed reducing device is employed.

As the leveler rolls are arranged in a top and bottom flight or group of rolls and each group can move vertically with respect to the other it is seen that connecting spindles and universal couplings are necessary. The universal joints are so made that they can move axially with respect to each other and thus take care of varying center distances between drive gear or pinion ends and leveling roll drive ends.

Motors Control Adjustments

In addition to the main drive motor, another motor lifts the top flight of rolls, which is carried in a yoke to provide screwdown adjustment. This yoke is carried in a saddle having a circular bearing so arranged that the yoke can turn with respect to the saddle. To tilt, a motor-operated shaft along its top carries a pair of eccentrics operating in guides on the yoke. Screwdown and the tilting motors control all the adjustments for the top flight of leveling rolls.

The bottom flight of rolls is varied in position by flexing in much the same manner as a bow is bent to shoot an arrow. This is accomplished by causing the backing up rollers, supporting the bottom rolls, to recede from or advance on these bottom rolls. A system of worms and worm wheels operate a vertical screw at each end of each support for adjustment. This gearing system is so designed that the center supports are elevated or depressed more than outside ones for a given movement of the control gearing. This causes leveling rolls to bow up or down. To drive this bottom backing up system a separate electric motor is used.

The main or leveling rolls have a journal at each end and revolve in brass bearings. They are well supplied with grease from a central source of lubrication supply. The gearbox is lubricated by an oil pump of the geared variety drive by a small electric motor and always operating with the machine. The oil after passing over and through the gearbox is collected in a sump and returned to the pump suction through an oil filter. The pump also supplies oil to the universal joints on the driving spindles.

This leveler design replaces a former type using back-up rollers several inches long and about the diameter of the leveling rolls, pictured in *Fig.* 3. Although the former design provided a fair degree of rigidity, it involved certain problems difficult to solve. For example, the long leveling rolls had a tendency to pick up deposits from the sheets and leveling rolls. Often their small diameter made proper bearing design difficult and frequent sticking of the back-up rollers marked the leveling rolls.

The new back-up rollers, instead, run free on heavy-duty antifriction bearings and being twice the size of the previous rollers, incur only half the surface wear.

Centralized Lubricators Offer Many Combinations

By James I. Clower

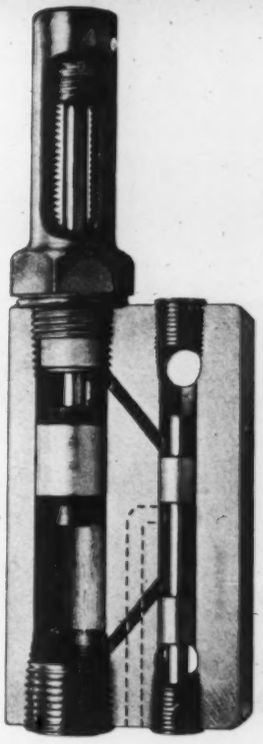


Fig. 1 — Heavy - duty control valve for handling heavy greases

WITH the intense interest focused of late on surface finish for bearings it is evident that increased attention to lubrication problems soon will follow. Regardless of finish, a bearing depends principally on the successful application of its lubricant. Centralized lubrication systems play an important part in achieving this object, and a review of such systems is therefore felt to be especially pertinent at this time.

Centralized lubrication systems might well be considered as a development and extension of the multiple-feed mechanical force-feed lubricator, one design of which is shown in the drawing on the next page, *Fig.* 4. This type of lubricator may be either a right or left-hand unit with ratchet, gear, or motor drive. Various features are available including vertical or horizontal types; one or more oil compartments for handling different oils; one to as many as 30 adjustable individual feeds; and reservoirs having capacities from one pint to four gallons. Finishes commercially obtainable are nickel-plated, painted, black enamel, polished brass, etc. Special designs include built-in heaters for outdoor service where temperature conditions are subnormal. Standard units develop 500 pounds per square inch; special types have been designed for producing 2000 pounds per square inch pressure. Most of these lubricators can be adjusted to feed from a fraction of a drop to several drops of lubricant per minute. They are reliable, positive, automatic, and reasonable in cost.

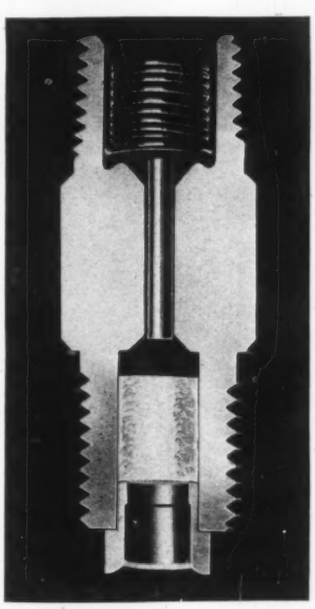


Fig. 2 — Left — Control valve used on small machines in conjunction with central pump units

Requirements as to number of feeds and capacity, nowever, are not sufficient for many machines. Moreover, the lubricator is not designed to handle the relatively heavy fluid greases required for certain heavy-duty machines.

Large numbers of bearings can be served by a centralized system using lubricants of a wide viscosity range. These systems differ from the multiple-feed mechanical force-feed lubricator in that measuring or control valves are provided at the bearings and the central pump unit discharges into a single feed line that supplies all bearings. The control valves

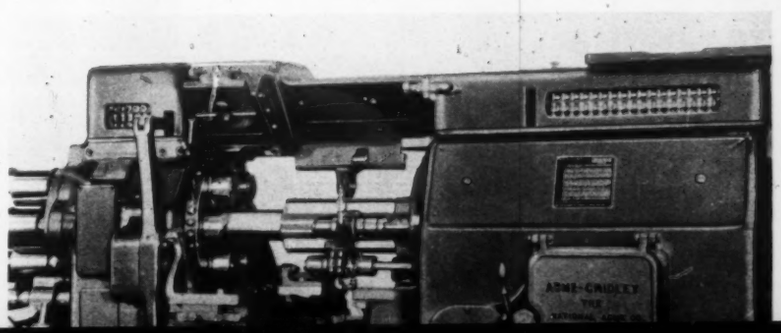


Fig. 3—Right—Automatic machine with centralized oiling system

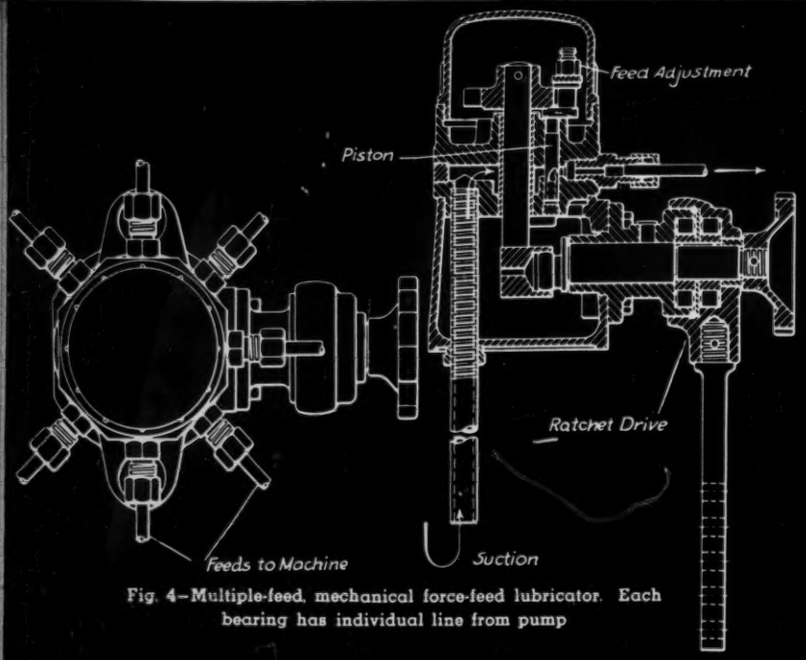


Fig. 4—Multiple-feed, mechanical force-feed lubricator. Each bearing has individual line from pump

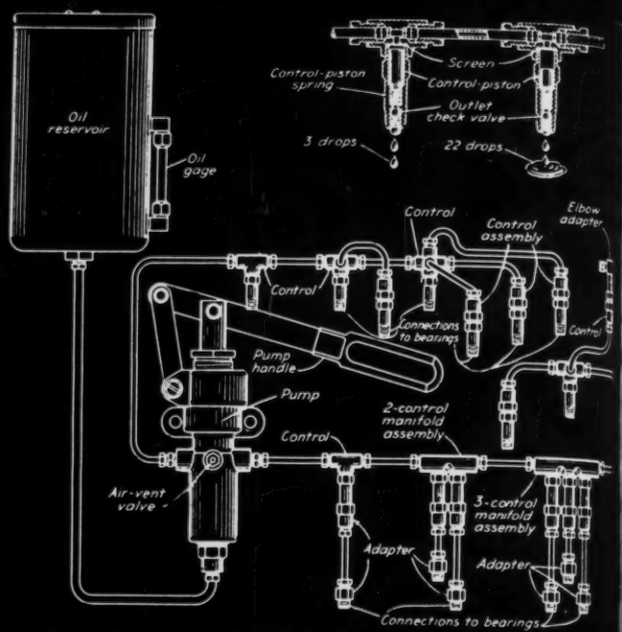


Fig. 5—Hand-operated centralized system. Valves in cross section meter the required lubricant

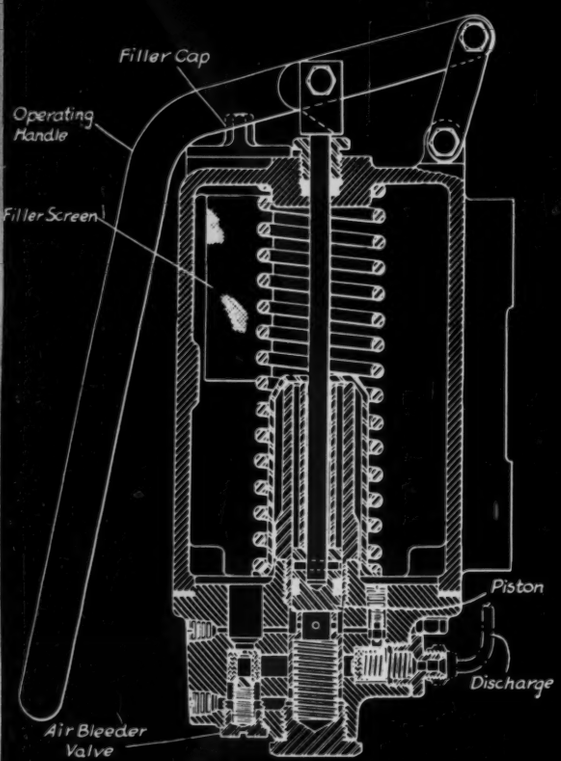


Fig. 6—Central pump for handling light lubricating oils

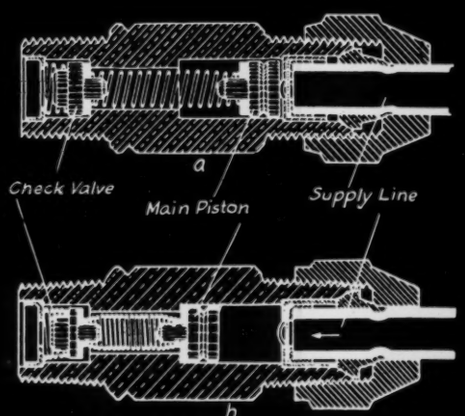


Fig. 7—Cross section of control valves. At *a* piston is in normal position. Full charge has been delivered by piston stroke at *b*

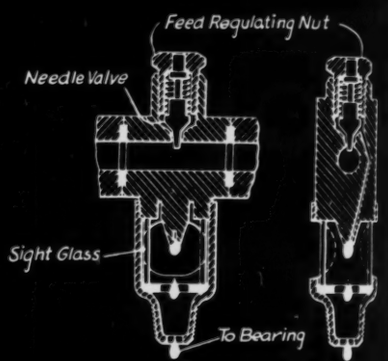


Fig. 8—Control valve for system shown in Fig. 9

Fig. 9—Fully automatic centralized oiling system utilizing individual metering valves

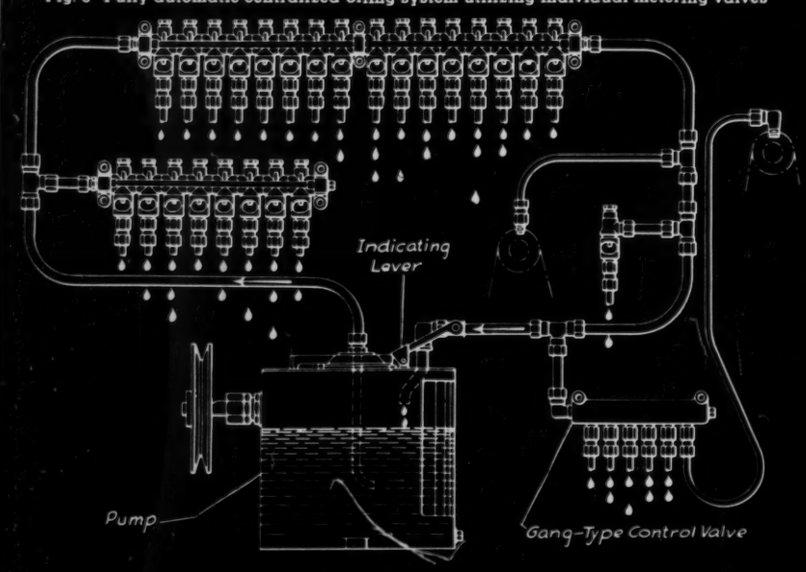
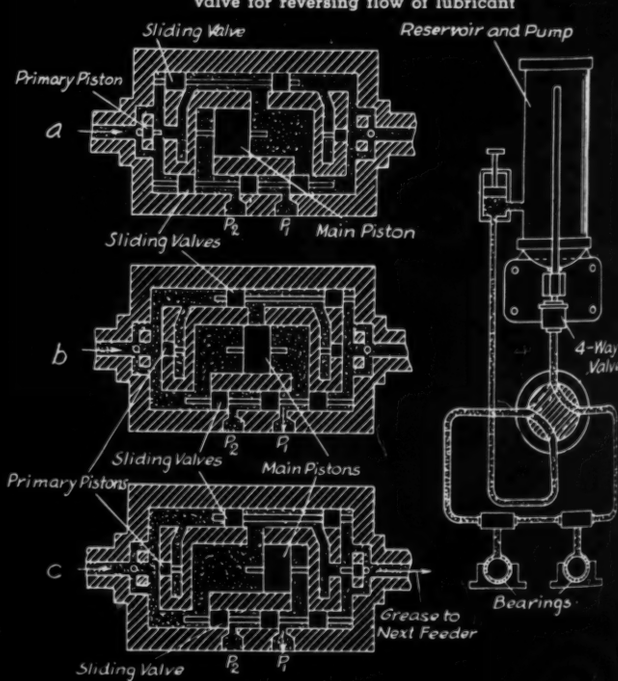


Fig. 10—Single-line greasing system employing four-way valve for reversing flow of lubricant



regulate the quantity of lubricant supplied to the bearings and are individually adjustable.

In *Fig.* 5 is shown a single-line, hand-operated system, consisting of an oil reservoir, a hand-operated pump, and control valves. For a single application the pump handle is operated only once with a continuous downward push until it stops solidly against the oil in the delivery line, after which it is returned to its top position. If an additional application is required, the operation is repeated after a few seconds.

Normal operation of the pump delivers the oil through the delivery line at a pressure of 500 pounds per square inch. When the pressure at any control valve reaches 75 pounds per square inch, the outlet check valve of the control opens and the piston in the control valve is forced downward by the pressure, oil being thus delivered to the bearing. The lower end of the piston, seating on the shoulder of the control body, acts as a cut-off valve and prevents additional oil from being forced in the bearing. After all the controls connected into a system have delivered oil to the bearings, releasing the pump handle relieves the line pressure and permits the spring under the piston to return it to its top position. Oil meanwhile passes from above to below the piston, through the clearance between the piston and cylinder, thus priming the control for the next operation. Control pistons are of three sizes to deliver respectively 3, 11, and 22 drops per operation.

Measures Lubrication

Sectional views of a central pump unit and control valve of a hand-operated system especially designed to handle light-bodied pure mineral oils are shown in *Figs.* 6 and 7. This is designed for textile machinery but is suitable for any light-duty machine requiring a light-bodied oil.

At *a* in *Fig.* 7 is shown the control in normal position and the valve chamber fully charged, but with no pressure on the supply line, which is full of oil. The main piston is moved forward under pressure of oil in the supply line to discharge the oil ahead of the piston past a check valve into the bearing. The valve is in the discharge position at *b*. After delivering a full charge of oil to the bearing, a fresh measured charge of oil enters the valve chamber behind the piston. When the piston returns to the right to its normal position, oil flows from the inlet chamber at the right of the piston to the spring chamber at left. This occurs when the pressure is relieved in the line at the pump.

Another design of a single-line, hand-operated centralized system designed to handle grease is shown in *Fig.* 10. The central pump forces grease into the control valve from left to right, as shown at *a*. A primary piston and sliding valves are moved to the right, as at *b*. This admits grease to the main cylinder and forces a main piston to the right. From the previous operation or cycle, the cylinder to the right of the main piston is full of grease which is forced through port P_1 to the bearing. In this position, grease is free to flow through, the control acting as part of the circuit, to operate the next control and lubricate the next bearing. The same process continues until each control in the system has operated to deliver a measured quantity of grease to its respective bearing. Then no more grease can be forced into the bearings until the four-way valve at the pump is reversed, which may be done manually or automatically. This valve reverses the grease flow in the circuit and the cycle is repeated, but from right to left. The line from the four-way valve can be any length and can have any number of control valves connected in series, each serving a bearing.

Designed for use with mechanically operated pumps,

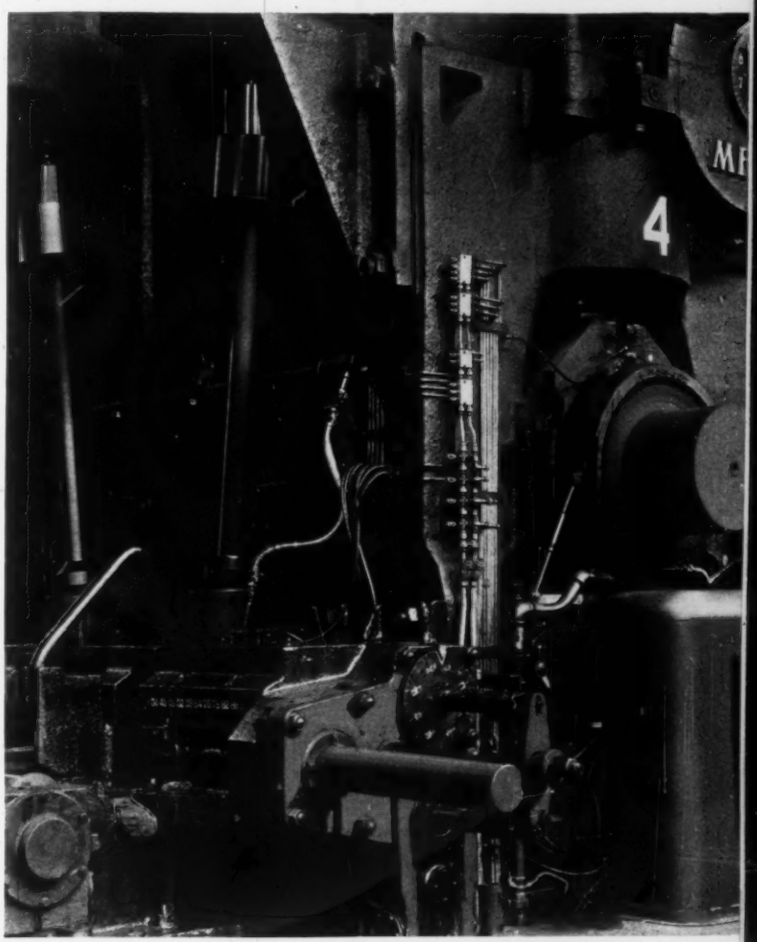


Fig. 11—Automatic centralized lubricating system applied to a large roughing mill and edge roll stand

the oil control valve shown in *Fig.* 2 delivers carefully metered oil to each outlet. The valve, containing a felt filter, flow metering pin and a check valve, prevents the pipe line from draining and the bearing oil from feeding back through the pipe line. The total amount of oil to be fed is determined by the operation and adjustment of the central pump unit. The control valves, however, are selected to feed a proportionate amount of this oil to each bearing. Feed rate of the valve depends on the clearance of the metering pin, each valve being stamped with a feed-rate number, the higher the number the greater the flow rate. Any number of bearings from one to one hundred or more can be served by one pump unit. Since the

(*Continued on Page* 96)

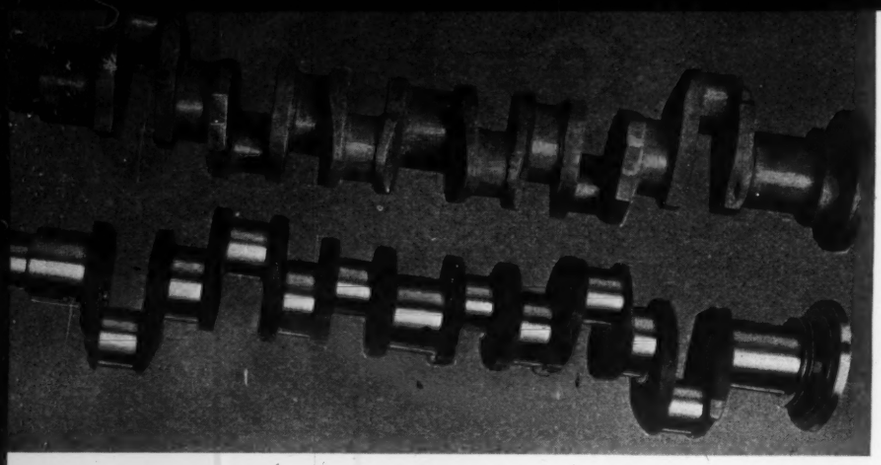


Fig. 1—Molybdenum cast iron crankshaft shown as cast and finished has desirable high strength-weight ratio

Moly Steels Cb

By Walter G. Patton
Climax Molybdenum Co.

ADDITIONS of molybdenum have far-reaching effects on the physical properties of steel. Increased hardenability, as well as higher tensile, impact and creep strengths of molybdenum alloys are continually extending their application. A case in point is a moly steel that was developed to meet requirements of the British defense program for a high strength steel that could be used for aircraft parts, in shipbuilding and for miscellaneous large forgings. In addition to developing essential mechanical properties and being adaptable to established production and fabrication methods, the steel was required to harden in large sections without distortion. Another special requirement was that the alloy must nitride satisfactorily, giving adequate hardness and mechanical properties without any tendency to cracking and spalling. Thirdly, the steel must case harden satisfactorily when carburized.

As a result of an extended program, a 3 per cent chromium, .5 per cent molybdenum steel was evolved which meets the above mechanical property and hardenability specifications satisfactorily. It forges well without any tendency to form hairline cracks. Case hardness developed on nitriding is resistant to cracking and spalling. After carburizing, the steel gives core properties equivalent to some chromium-molybdenum-nickel steels. Further, the steel resists any tendency to embrittlement at elevated temperatures which tendency is a common weakness of plain carbon as well as certain alloy steels. It is unusual for a single alloy steel to meet such stringent property specifications without violating some of the special processing restrictions that were imposed on this particular analysis.

Development of "tailor-made" alloy steels to meet exacting engineering requirements is not necessarily confined to defense programs. Peacetime industries have difficult engineering problems, too—for instance, the oil industry which is said to use more alloy steels today than the automobile industry. With 10,000 to 15,000-foot wells becoming almost commonplace, metal-

TABLE I

Mechanical Properties of Molybdenum Steels

Steel SAE	Heat Treatment*	Tensile Strength (000 psi)	Yield Point (000 psi)	Elongation (% in 2")	Reduction in Area (%)	Brinell Hardness	Izod Impact (ft.-lb.)
X4130	Annealed	90	62	30	62	180	..
	W.Q. T. 1000°F.	170	145	19	56	320	60
	W.Q. T. 1200°F.	142	120	22	63	270	100
4140	Annealed	100	70	25	50	200	..
	O.Q. T. 1000°F.	165	140	18	55	320	44
	O.Q. T. 1200°F.	135	115	22	62	260	81
4150	Annealed	110	85	23	42	210	..
	O.Q. T. 1000°F.	188	162	16	51	370	33
	T. 1200°F.	155	132	19	60	300	57
4340	Annealed	125	100	16	42	250	..
	O.Q. T. 1000°F.	185	160	18	52	355	48
	T. 1200°F.	150	130	20	57	300	86
4640	Annealed	100	90	22	40	200	..
	O.Q. T. 1000°F.	165	136	18	54	330	41
	T. 1200°F.	135	110	21	60	270	66
4650	Annealed	110	90	25	45	220	..
	O.Q. T. 1000°F.	173	140	18	52	330	35
	T. 1200°F.	137	110	22	56	260	58

*W.Q. = Water Quench. O.Q. = Oil Quench; T. = Temper;

TABLE II

Brinell Hardness of Various Sections from ½-inch to 6 inches‡

SAE Stee and Treatment*	½-inch Section S, M & C	1-inch Section S	M	C	2-inch Section S	M	C	3-inch Section S	M	C	4-inch Section S	M	C	6-inch Section S	M	C
4130—W.Q.																
800°F. Draw	375	375	365	365	375	310	280	370	265	235	345	240	215	340	230	200
1000°F. Draw	300	305	300	300	300	255	250	300	250	230	290	225	205	280	215	200
1200°F. Draw	250	250	245	245	250	225	210	245	205	200	235	205	200	225	200	190
X4130—W.Q.																
800°F. Draw	380	380	380	380	375	350	305	375	310	280	350	290	245	340	260	210
1000°F. Draw	325	325	325	325	325	305	285	320	280	255	310	265	240	270	230	200
1200°F. Draw	270	270	270	270	260	230	220	250	215	205	240	215	205	235	205	190
4140—O.Q.																
800°F. Draw	390	390	390	390	380	370	360	380	365	325	365	345	280	350	325	260
1000°F. Draw	325	325	325	325	320	310	300	320	290	275	320	290	260	300	260	225
1200°F. Draw	250	250	250	250	250	240	240	250	225	220	250	225	220	250	220	215
4150—O.Q.																
800°F. Draw	450	450	450	450	450	450	450	440	425	400	440	425	390	425	405	350
1000°F. Draw	365	365	365	365	365	365	365	370	340	330	340	320	300	335	300	270
1200°F. Draw	310	310	310	310	310	310	310	310	285	275	290	260	250	280	240	230
4640—O.Q.																
800°F. Draw	400	390	390	390	390	370	350	390	280	260	370	250	230	350	235	210
1000°F. Draw	340	330	330	330	310	285	285	310	265	250	300	240	220	280	225	205
1200°F. Draw	260	260	260	260	260	250	240	260	240	230	250	220	210	240	215	200
4340—O.Q.																
800°F. Draw	410	410	410	410	410	410	410	410	400	370	405	400	355	395	360	320
1000°F. Draw	355	355	355	355	355	355	355	355	350	320	355	340	315	325	280	260
1200°F. Draw	310	310	310	310	310	310	310	310	300	290	290	270	260	285	250	240

*W Q. = water quench; O.Q. = oil quench; ‡S = surface; M = half way; C = center.

Combine High Physicals, Workability

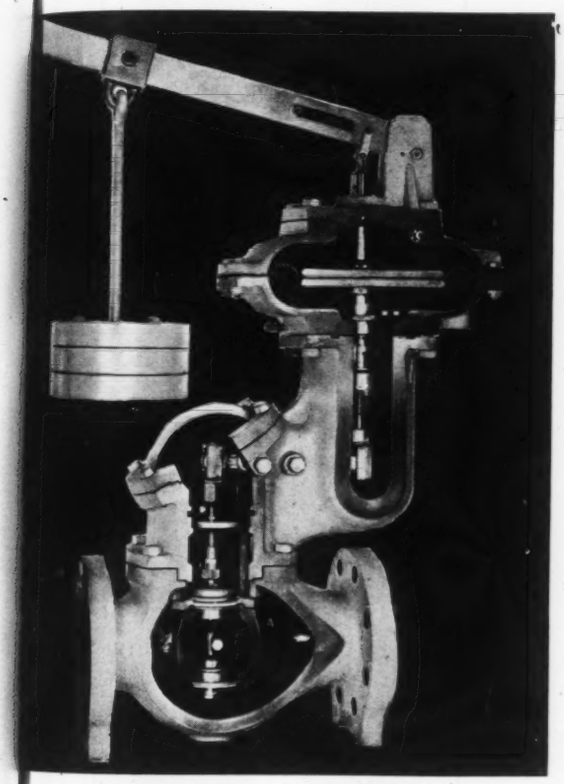


Fig. 2—Pressure regulator body cast of nickel - chromium - molybdenum iron has high corrosion resistance

lurgists and oil production executives have been co-operating to the fullest extent to develop competent materials for the oil industry.

Tool joints, for example, are the husky, two-piece couplings which make possible the assembling and disassembling of oil well drill strings. Many oil wells average 132 tool joints per mile of drill pipe, making a total of 375 joints for a 15,000-foot well. Fatigue failures at these all-important joints were once fairly common in deep wells; fishing jobs resulting from such failures have been known to cost a drilling contractor as much as $100,000. Recently, such failures have been largely avoided by the use of a chromium-molybdenum-nickel steel known unofficially as "4245."

The metallurgical approach that ultimately led to the development of a satisfactory steel for tool joints was the addition of a proper amount of molybdenum to a chromium-nickel steel with .45 per cent carbon. In this instance, the molybdenum addition not only enhances the mechanical properties of the steel and assists in developing uniform hardness throughout the piece but also permits the use of relatively high tempering temperatures while retaining adequate physical properties. Because a high tempering temperature can be used (without substantial loss of strength), the new steel is freer from quenching stresses. These stresses, if retained in the steel, contribute to premature fatigue failure and loss of impact strength. The fact that remarkably uniform properties are developed in regular production is a tribute to the system of metallurgical control as well as a demonstration of the consistent response of the steel to heat treatment.

Use of specialized compositions to improve engineering performance is not confined to steel. Metallurgical investigation of cast iron has also resulted in the development of new alloy irons that have established splendid records in service. A typical example is brake drums for busses and trucks. These parts generally fail in service as a result of heat checking and loss of strength at elevated temperatures. Research has indicated that resistance to heat checking can be improved by increasing total carbon content. However, the higher the carbon, the weaker the iron, both at room and elevated temperatures.

A reply to this metallurgical dilemma was found by adding molybdenum and vanadium to improve the strength of the iron while retaining high carbon to resist heat checking. After considerable investigation a molybdenum-vanadium alloy was found which offered a

Fig. 3—Molybdenum steel and iron in this diesel head effected reduced production costs

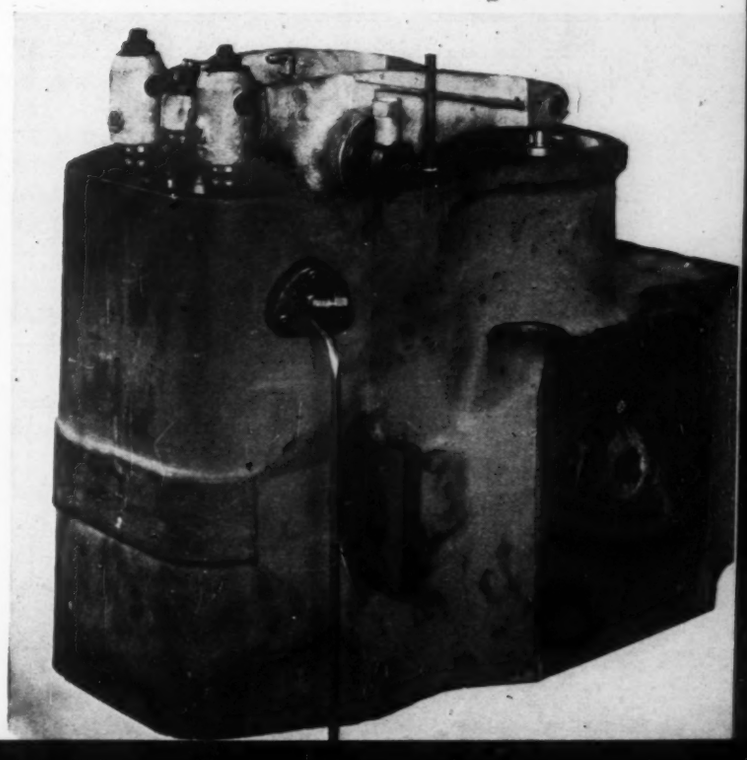


TABLE III

Specific Applications for Molybdenum Alloy I

Typical Applications	Chemical Analysis, Per Cent								Section (inches)	Weight (ponnds)	Hardn Brine
	Si.	T.C.	C.C.	Mn.	Ni.	Mo.	Cr.	Other			
Automotive											
Brake drums, Truck	2.4	2.9	.70	.70		0.50			$\frac{3}{16}$–1$\frac{3}{4}$	22–167	180/20
Brake drums	1.65	3.60	.91	.80	0.10	0.77	.23				
Brake drums, Bus	1.81	3.42		.67		0.55		.16 V.			217
Crankshafts, Auto & diesel	2.60	2.65	.75	.90	1.12	1.12	.15		$\frac{3}{4}$–4	80–2250	290/32
Crankshafts, Small engines	2.10	2.87	.87	.65	0.87	0.50	.20[4]		1$\frac{1}{2}$–3	15– 40	220/26
Cylinder blocks	1.90	3.30	.70	.80		0.17	.17		$\frac{3}{16}$–2	278	212/22
Cylinder heads, Diesel	1.60	3.22	.82		0.05	0.42		.07 Ti.	$\frac{1}{2}$–2$\frac{1}{2}$	500–5000	223/25
Cylinder liners, Truck	2.30	3.10	.60	.80	0.40	0.40	.40		$\frac{1}{2}$–$\frac{7}{8}$	19– 24	248/27
Exhaust manifolds	2.12	3.00		.77		0.50[4]	.25[4]		$\frac{3}{16}$–$\frac{1}{2}$	50	255[4]
Main liner, Marine diesel	1.35	2.95	.90	.70	1.12	0.30	.25		2$\frac{1}{2}$–4	4000	190/22
Chemical machinery											
Steam pressure casting	1.35	3.05	.65	.85		0.25			$\frac{3}{4}$–1$\frac{1}{2}$	2000–7000	190/21
Compressors and pumps											
High pressure	1.30	3.00	.85	.90	1.00	0.70	.50		2 –6	4000–16000	269-29
Crushing and grinding equipment											
Gyratory crusher shell	2.00	2.80			1.40	.75					
Coke crusher segments	1.15	3.15		.70		.50	1.00	1.00 Cu.			
Machine castings											
Lathe beds	2.00	3.20		.85		.37	0.20		1 –2		196/21
Sleeve, Gear cutting machine	2.10	3.17		.80		.50			1$\frac{1}{4}$	100	230[8]
Mold machine casting	1.60	3.00		.80	0.90	.60	0.25				269
Railroad castings											
Cylinder liners	1.60	3.20		.90		.32	0.32				217/21
Cylinders, Locomotive	1.50	3.00		.90		.75					255[10]
Miscellaneous											
Cams, Turbine control	2.05	3.20	.62	.80	0.50	.50			$\frac{3}{4}$	8	234/24
Cylinders, Steam engine	1.50	3.00		.90	1.35	.40	0.50		2 –4	2500–3000	240 Mi
Gears, Machinery	2.55	2.85	.82	.62	1.50	.50	0.42		$\frac{1}{2}$–3	10– 50	
Gears, Heavy duty	2.35	2.95	.77	.60	2.00	.90	0.20		$\frac{1}{2}$–1$\frac{1}{2}$	Up to 150	
Grate bars	1.75	3.25		.70		.40	0.50				
Rolls for rolling mills	1.50	3.50		.55		.55	1.00		1–1$\frac{1}{2}$	1000–5000	243/30

[1] 180-207 light drums; 223-255 heavy drums.
[2] 1.2 inch diameter, 12 inch supports.
[3] 2 inch section.
[4] Maximum.
[5] 1.25 diameter, 18 inch supports.
§Courtesy American Foundrymen's Association.
[6] .875 diameter, 12 inch supports.
[7] 2 inch section.
[8] As cast.
[9] Laboratory heat.
[10] On test bar.

TABLE IV

Composition and Mechanical Properties of Molybdenum Cast St

Steel Type	Composition							Heat Treatment*	Tensile (psi.)	Yield Pt. (psi.)	El (2"	R.A. %
	C.	Mn.	Si.	Mo.	Cr.	Ni.	V.					
C-Mo	.25	0.70	.34	.56				N & T 1250°F.	77,500	48,000	30	56.2
C-Mo	.35	.69	.31	.45				N & T 1250°F.	83,500	55,200	24	39.5
C-Mo	.40	0.80	.38	.47				N & T 1250°F.	90,000	60,000	20	33.3
Mo-V	.51			.31			.05	A,Q & T 1320°F.	101,000	73,000	25	57.9
Cr-Mo	.31			.25	0.68			AC 1650°F., T 1200°F.	89,500	59,800	22	44.0
Cr-Mo	.42			.23	0.82			AC 1650°F., T 1250°F.	109,350	75,250	19	33.1
Cr-Mo	.32			.20	0.95			OQ 1650°F., T 950°F.	176,500	170,000	9	24.6
4/6 Cr-Mo	.20			.58	5.16			AC 1750°F., T 1200°F.	97,000	68,500	22	50.2
4/6 Cr-Mo	.30			.49	4.83			AC 1800°F., T 1250°F.	111,500	87,800	20	45.3
Mn-Mo	.30	1.25		.35				N & T 1250°F.	92,500	65,300	23	52.5
Mn-Mo	.33	1.60		.35				AC 1650°F., T 700°F.	133,640	101,240	15	44.0
Mn-Mo	.28	1.29		.30				AC 1700°F., AC 1500°F., T 1200°F.	84,500	64,750	24	60.5
Mn-Mo	.28	1.29		.30				AC 1700°F., WQ 1500°F., T 1300°F.	87,250	62,500	24	62.5
Mo-Ni	.22			.30		1.46		AC 1650°F., T 1200°F.	87,500	58,000	22	48.6
Mo-Ni	.35			.30		1.75		AC 1650°F., T 1200°F.	100,000	70,000	23	50.0
Ni-Cr-Mo	.30			.21	0.54	1.45		AC 1650°F., T 800°F.	124,000	83,500	3	37.5
Ni-Cr-Mo	.30			.21	0.54	1.45		AC 1650°F., T 1200°F.	104,000	79,000	15	46.0
Ni-Cr-Mo	.30			.27	0.55	1.68		WQ 1650°F., T 1150°F.	149,500	135,000	12	32.0
Ni-Cr-Mo	.30			.21	0.54	1.45		OQ 1650°F., T 1200°F.	118,500	94,500	16	47.0

[1] Charpy [2] Izod
*N = Normalize; AC = Air Cool; OQ = Oil Quench; WQ = Water Quench; T = Temper, A = Anneal.
† Courtesy Steel Founder's Society.

Transverse Load, lb.	Transverse Defl. In.	Tensile psi.	Remarks
6000[2]	.14	57,000	Impact 1.2 inch bar on 6 inch centers 60-90 ft. lb. Used for high strength impact resist., thermal stability.
3025[5]	.30	45,400	Impact 54 ft. lb. Excellent service life.
7300[2]		60/75,000[3]	Performance equal to or superior to steel. Excellent fatigue properties.
3250[5]	.28	60,000	Wear resistance, strength, impact resistance.
4800[2]	.15	38/41,000	High hardness in bores, freedom from cracks, good machinability.
3100[5]	.30	45/51,000	High strength, close grain, resilience & wear resistance.
5000[2]		46/54,000	Used for wear resist., machinability. Liners are heat treated.
4400[6]		50,000	Used to obtain increased strength, reduced breakage.
5200[2]	.12	45/50,000	Resistance to wear and heat.
5600[2]	.18	42,000	Used for strength, wear and abrasion resistance.
		60,000	Used for high strength and density at machinable hardness.
			Good wear, impact resistance.
			Good wear resistance.
			Flame hardened. Good machinability. Satisfactory wear.
3000[5]	.32	48,000	Heat treated. Used for response to heat treatment. Wears better than tool steel guides.
		56,000	Good machinability; wear resistance.
			Add .3% Si. late. Good wear resistance.
6000[2]	.17	55,000	.5% Si. added at spout. Eliminates cracking.
3000[5]	.32	48/50,000	Wear resistance. Apparently wears as well as tool steel cams.
		50,000	High strength and wear. Thermal stability up to 800°F.
3200[5]	.27	55,000	Brinell hardness (heat treated) 450-550. Used for wear resistance, strength and shock resistance.
3500[5]	.37	65,000	Brinell hardness as cast 280-300. Used for wear resistance. High strength. Good impact. Heat treated.
			Good resistance to growth; long life.
3500[5]	.25	30/50,000	Used for wear resistance.

R.A. %	Hardness Brinell	Impact (ft. lb.)	Remarks
56.2 39.5 33.3	168 200		Good properties after normalizing treatment; high strength at elevated temperatures. Typical applications: rolls, locomotive and machinery parts subject to shock.
37.9		43[1]	Centrifugally cast gun.
44.0 33.1 24.6	190 235	30.2[2]	Use: brackets, crankshafts, gears, locomotive parts, heavily stressed machine parts. Good abrasion resistance. Elevated temperature strength.
50.2 45.3	196		Oil pump impellers, oil pump casings, yokes. Good creep strength.
52.5 44.0 60.5 62.5	187 292 179 187	 2.2[2] 45.3[1] 57.0[1]	Moderate cost; deep hardening. Uses: automotive, tractor, excavating machinery and freight car castings, sprockets, gears, etc.
48.6 50.0		56.0[2] 44.0[2]	Uses: Rolling machinery castings, heavy duty gears and pinions, mining machinery castings, locomotive parts, cargo hooks. Can be carburized.
37.5 46.0 32.0 47.0			Combine high strength, toughness, resistance to fatigue. Typical applications: sprockets, gears, pinions, dredge parts, impeller castings, crusher heads.

good balance between cost and performance. Latest available reports indicate the molybdenum-vanadium brake drums are performing in a satisfactory manner and will continue to operate well over 200,000 miles before replacement becomes necessary.

The 600-pound pressure, three-inch regulator shown in *Fig.* 2 has a body of nickel-chromium-molybdenum cast iron incorporating the important features of high strength, mild corrosion resistance and machinability. Cylinder liners, heads, pistons, timing gears and high pressure fittings are among the many parts of the diesel engine shown in *Fig.* 3 which are made of molybdenum cast steel.

While the above hand-picked examples may seem exceptional, they are not unusual. Molybdenum alloys are comparatively recent developments. The fact that they are standard today, however, for many engineering applications fully justifies their economic position; otherwise the new alloys to be discussed presently would never have been able to replace other materials.

Considerable data on the mechanical properties of molybdenum steels are available to the design engineer. Many of these steels are used in machine applications. Unfortunately, however, existing data are often either inadequate for the engineer's needs or the records are so widely scattered that they lose much of their potential value. Under these circumstances it would appear that the machine designer would derive some benefit if essential data on all molybdenum steels and cast irons and their machine applications were brought together in one place. The potential value of such a data summary would be increased if an effort were made to include the latest available published data as well as unpublished information furnished by private sources. This has been done in the present article.

Hardenability Is Reason for Specification

Data on mechanical properties and heat treatment of molybdenum carburizing steels have been published by steel suppliers and steel producers for a number of years and are known by most engineers. One shortcoming of existing S. A. E. data sources, however, is that only meager information is available on the ability of S. A. E. steels to harden in large sections. The properties given in TABLE II are after quenching and tempering at 800, 1000 and 1200 degrees Fahr. in sections from ½ to 6 inches. Need for this information becomes clear when it is remembered that the greater hardenability of the molybdenum steel is frequently the reason it is specified in preference to plain carbon or other alloy steels. Tensile strength of the steels, treated in large section, can be approximated by multiplying the brinell hardness by 500.

The foregoing discussion applies to S. A. E. steels in the forged or rolled condition. Comparable data on cast molybdenum steels have not been generally available heretofore.

TABLE IV has been prepared showing the analyses, heat treatment and mechanical properties of typical molybdenum cast steels used for machine applications.

(*Concluded on Page* 106)

Factors Influencing Power L

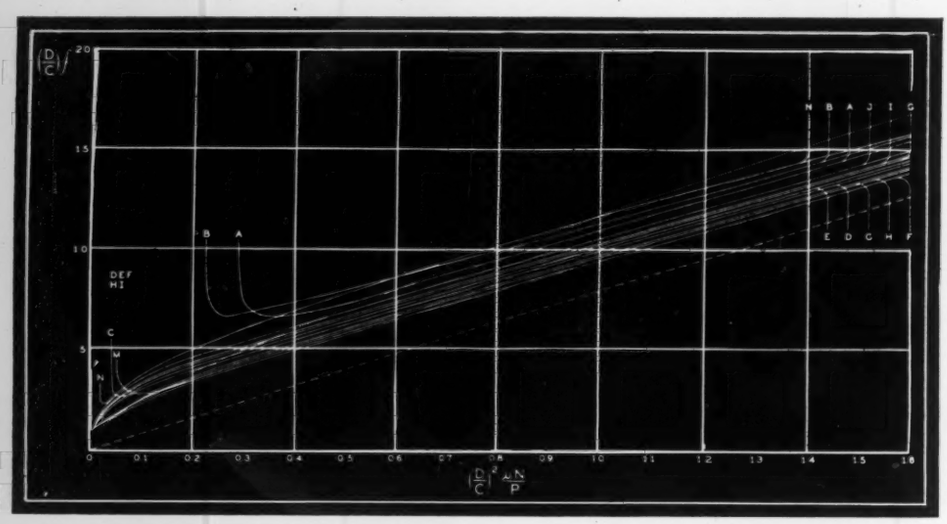
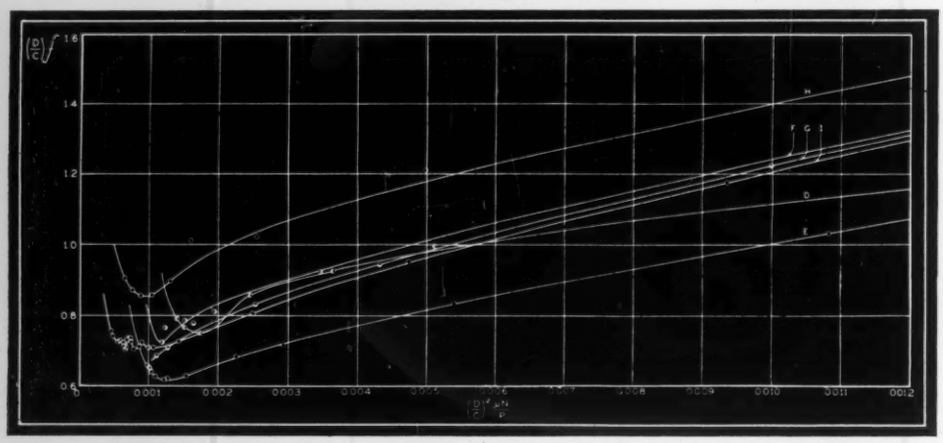


Fig. 1—Curves show the affect on the friction coefficient of various surface-finishes of steel journals running in babbitt. Letters on the curves refer to the steel journal finishes indicated in Table 1

Fig. 2—These curves are a portion of those in Fig. 1 on a larger scale



Effects of Surface Finish*

VARIOUS commercial surface finishes produced on steel shafts have little effect on the operation of a journal bearing in the region of hydrodynamic lubrication. At higher loads and lower speeds, however, this theory is insufficient and, though a complete theory is lacking, it has been found empirically that many other physical properties of the system affect the behavior of lubricated journal bearings. These properties are of two general kinds, those of the lubricants and those of the bearing surfaces.

While the existence of an influence of surface finish on bearing performance has long been recognized no thorough study has been made, largely because a quantitative measure of surface roughness was lacking. Recently a number of methods have been developed.

One of these methods gives as a reading on a meter a number which is related to the root-mean-square deviation of the surface from a median plane. This instrument is called a profilometer and the surfaces used in the present work were measured by means of it.

Performance of the journal bearings was studied by measuring the friction coefficient as a function of the geometry and the operating variables. The minimum of this function is a measure of the load capacity of the bearing. Bearings were a tin-base babbitt with steel backing, such as are used for the main and connecting rod bearings of automobile engines. Their roughness was 6 to 10 microinches.

All but one of the test shafts were made of an S. A. E. 1040 steel heat treated to a hardness of 200 brinell. The exception was shaft *M* described in TABLE 1 which was hardened to 450 brinell. Surfaces of varying kinds and degrees of

TABLE I
Finish vs. Friction Factor

Shaft	Type of finish	Surface roughness Traverse, micro-inches	Surface roughness Parallel, micro-inches	d/c	Value* of $\left(\frac{d}{c}\right)^2 \frac{ZN}{p}$
K	Knurled	550	..	....	.....
A	Turned	130	50	1150	0.38
L	Gritblasted	110	..	....	.....
B	Ground	70	70	1200	0.25
C	Ground	50	50	630	0.06
M	Gritblasted	30-50	..	280	0.12
D	Ground	14	..	520	0.0017
E	Ground	13	..	540	0.0013
N	Chemically etched	11	..	280	0.024
F	Ground	7	8	500	0.0012
G	Ground	6	7	480	.....
H	Ground	4	6	480	0.0010
I	Superfinished	1	..	500	0.0008-0.0011
J	Superfinished	1	..	870	.....

*At minimum friction coefficient.

* Abstracted from a paper presented before a recent meeting of the A.S.M.E. by its authors, J. T. Burwell, J. Kaye, D. W. van Nymegen and D. A. Morgan of the Massachusetts Institute of Technology.

L$_s$ in Bearings

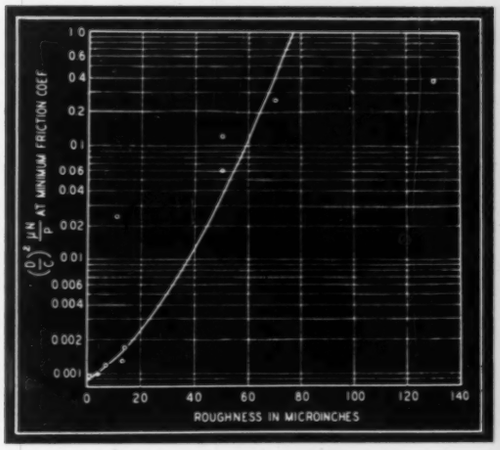


Fig. 3—Variation of minimum friction coefficient with surface roughness is shown by curves

roughness were put on the shafts. These are also tabulated in TABLE 1 and are, for the most part, self explanatory. The knurled surface was produced by grinding a surface which had originally been knurled. The result gave diamond shaped areas with a surface roughness of about 5 microinches separated by V-shaped grooves .005 inch deep and 1/32-inch apart. This composite surface had a roughness of 550 microinches on the profilometer although it is questionable what significance this reading has.

All the shafts were tested without being run in. To simulate service conditions the speed was about 1500 revolutions per minute although some measurements were taken at 200 and 1800 revolutions per minute to make sure that the friction coefficient actually depended on the expression ZN/p.

As is well known when comparing results on different sets of shafts and bearings $(d/c)f$ should be plotted against $(d/c)^2ZN/p$ rather than plotting the friction coefficient directly against ZN/p.

Fourteen samples in all were tested. Data from two typical runs, one on a rough surface and one on a relatively smooth one, are shown in TABLES II and III. Calculated values of d/c were plotted against p/ZN and the extrapolated value found thereby was then used to calculate the last two columns in the tables.

Complete results are plotted in *Figs.* 1 and 2, *Fig.* 2 being a small region of *Fig.* 1, near the minima for the smoother surfaces, on a much enlarged scale.

Nomenclature

W	=	total bearing load, lb.
p	=	unit bearing load, psi
l	=	axial length of bearing, in.
d	=	journal diameter, in.
F	=	frictional force at journal surface, lb.
L	=	power loss, kw.
N	=	speed of journal, r.p.m.
f	=	coefficient of journal friction
t	=	temperature, Fahr.
Δt	=	temperature rise, Fahr.
Q	=	rate of oil flow to bearing, g.p.m.
δ	=	specific heat of oil, B.t.u. per gal. per deg. Fahr.
Z	=	absolute viscosity, centipoises $\frac{\text{dyne sec}}{\text{cm}^2}$
ρ	=	specific gravity of oil
ϕ_1, ϕ_2, etc.	=	functions
c	=	diametral clearance, in.

In two of the runs the limiting load of the machine was reached without failure occurring as is shown by curve *G* in *Fig.* 2. Curve *J* also does not show a minimum but it lies outside the region of *Fig.* 1. In the case of the knurled shaft *K* and the grit blasted shaft *L* signs of incipient seizure appeared even at the lightest loads available so that it was impossible to obtain values of d/c. However, assuming any reasonable value for d/c gives results in general agreement with the other data.

Several of the curves, such as curve *I* in *Fig.* 2, showed fluctuations near the minimum which is characteristic of failure in babbitt bearings. Apparently when the load and temperature become too high locally the babbitt flows and then the shaft reseats itself in the bearing. In such cases the first minimum was taken as the true one since with the later ones the configuration of the bearing was different.

Since the slopes of the curves in *Fig.* 1 are dependent on the values of d/c, this spread could be due en-

TABLE II

Typical Data from a Journal-Bearing Test

(Shaft *A:* Turned surface, 130 microinches. Extrapolated value of d/c=1150)

Speed of journal, rpm	Film temperature °F	Viscosity of lubricant lb min/in.^{2}	Unit load psi	Friction torque lb-in.	d/c	$p/ZN \times 10^{-5}$	$(d/c)f$	ZN/p $(d/c)^2$
1489	117	14.75×10^{-8}	22.8	7.78	942	1.06	84.4	12.75
1497	122	12.75	45.6	8.33	1162	2.40	44.5	5.54
1509	125	11.70	68.5	8.57	1292	3.88	30.9	3.53
1509	127	11.05	91.2	8.71	1391	5.46	23.6	2.41
1468	128	10.80	136.8	8.59	1430	8.62	15.53	1.53
1470	130	10.40	136.8	8.16	1410	8.88	14.73	1.478
1466	132	9.77	182.5	8.33	1550	12.75	11.28	1.037
1470	132	9.71	207	8.92	1660	14.50	10.70	0.910
1450	133	9.68	228	8.75	1658	16.25	9.45	0.815
1464	134	9.30	251	8.92	1740	18.45	8.75	0.717
1466	135	9.04	274	9.75	....	....	8.78	0.640
1468	136	9.00	278	9.67	....	....	8.57	0.629
1462	137	8.47	296	9.25	....	....	7.69	0.554
1470	138	8.41	319	9.75	....	....	7.53	0.512
1468	139	8.25	342	10.42	....	....	7.52	0.468
1462	141	7.82	379	10.00	....	....	6.53	0.400
1460	142	7.68	402	10.68	....	....	6.57	0.369
1465	148	6.68	430	12.70	....	....	7.32	0.300

TABLE III

(Shaft *D:* Ground surface, 14 microinches. Extrapolated value of d/c=520)

1485	105	20.3×10^{-8}	22.8	4.13	362	0.754	20.2	3.58
1490	110	17.6	54.8	5.96	604	2.08	12.15	1.29
1487	112	16.8	86.8	6.29	670	3.47	8.09	0.780
1500	115	15.5	118.7	6.67	764	5.10	6.26	0.530
1500	127	11.2	347	8.75	1385	20.60	2.81	0.1315
1497	136	8.89	584	9.50	....	....	1.81	0.0616
1488	144	7.27	822	11.17	....	....	1.52	0.0357
1486	153	5.95	1028	12.83	....	....	1.395	0.0232
1498	161	4.97	1260	14.33	....	....	1.27	0.0160
1484	174	3.86	1717	16.50	....	....	1.078	0.00904
1482	192	2.74	2170	19.32	....	....	0.995	0.00506
1480	205	2.42	2650	22.0	....	....	0.925	0.00365
1482	221	2.01	3260	25.0	....	....	0.855	0.00247
1492	235	1.82	4190	28.0	....	....	0.750	0.00175
1486	246	1.70	4500	30.8	....	....	0.765	0.00152
1480	249	1.67	4740	33.5	....	....	0.790	0.00141

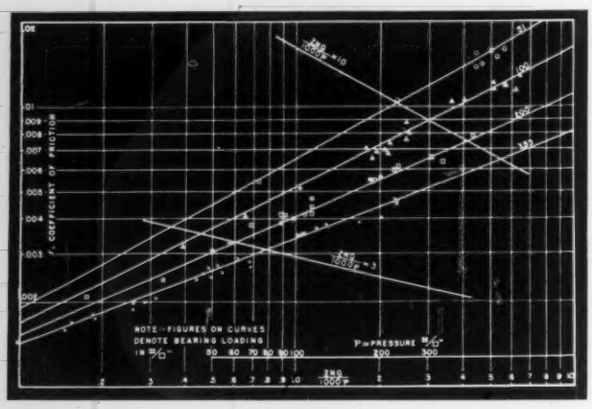
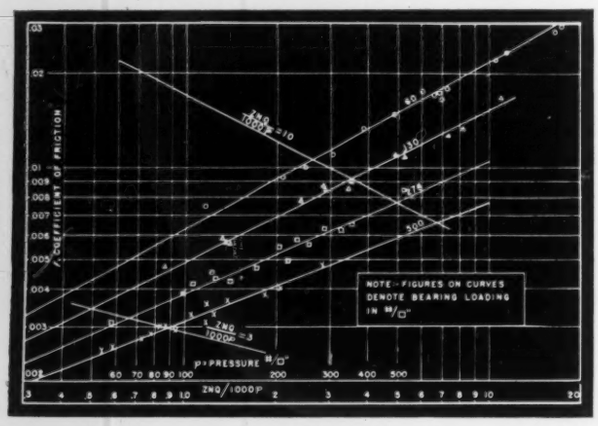


Fig. 4—Friction coefficient varies exponentially with the bearing factor for a 6x8-inch, 130-degree lining

Fig. 5—These curves for a 6¼x8-inch, 120-degree lining afford a comparison with Fig. 4



tirely to inaccuracies in values of d/c which, while difficult to estimate, are probably of this order of magnitude.

In an effort to determine the accuracy in the measurement of d/c the following experiment was tried. One d/c determination was made at light loads and then a small amount was carefully ground off the surface of the shaft and a second determination was made without disturbing the bearing shells. The amount removed or the change in diameter could be measured fairly accurately. The second measurement of d/c while in the right direction would differ as much as 50 per cent from the value measured by the micrometer.

It may be concluded then that the surface finish has no effect on the upper portions of the friction curves where the bearings are operating under conditions of hydrodynamic lubrication. The two roughest shafts A and B may be exceptions to this in that their curves do lie above all the others.

While all the experimental curves follow the same direction in general agreement with the theory, they each show a minimum at widely scattered points along this curve. The value of $(d/c)^2ZN/p$ at which each minimum occurs is tabulated in TABLE I and is plotted against the roughness of the shaft as measured transversely in *Fig.* 3. It is evident that the smoother the finish the lower the value at the minimum. This means that for a given clearance ratio d/c and a given speed and operating viscosity the smoother shaft will have the greater load capacity. It is seen that the improvement is greatest for the rougher surfaces, there being a factor of almost two hundred between a surface of 70 microinches and a surface of 13 microinches, while from 13 microinches to 1 microinch the improvement is slight.

In drawing the curve no weight was given to the point for the turned surface because of the difference between the longitudinal and transverse readings of roughness and the fact that there is some question as to which one is the more significant. (The point for the knurled surface lies far to the right of the plot.) The transverse reading for the turned surface is plotted because this is the larger one and as such would always seem to be a limitation on the load capacity no matter how smooth the tool marks were.

Other investigators have arrived at the opposite conclusion, i.e. the smoother the surface the less the load capacity. However, a reciprocating motion between two cast iron and two hardened steel surfaces were used in these tests with consequent severe lubricating conditions. In the case of the hardened steel it was found that sandblasting or gritblasting one of the surfaces increased the load bearing capacity threefold.

In the work described herein summarized in *Fig.* 3, the wide scatter of the points for the rougher surfaces shows that from the point of view of journal bearing performance the profilometer reading alone is not suf-

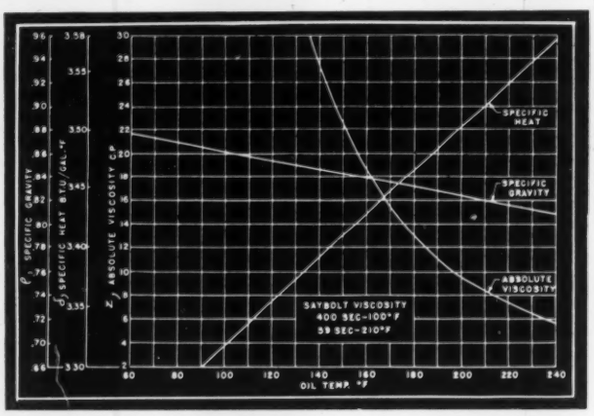
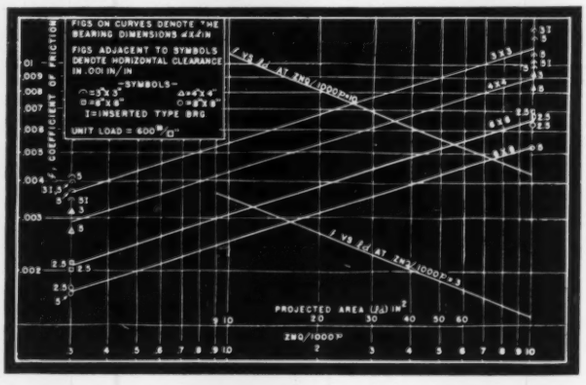


Fig. 6—Characteristics of lubricant used in these tests approximate those of a S.A.E. 30 oil

Fig. 7—Curves similar to Figs. 4 and 5 show the effect of a length to diameter ratio of 1 with a 600 pounds per square inch load on projected area


FIGS ON CURVES DENOTE THE BEARING DIMENSIONS d"x1"
FIGS ADJACENT TO SYMBOLS DENOTE HORIZONTAL CLEARANCE IN .001 IN/IN
-SYMBOLS-
I=INSERTED TYPE BRG
UNIT LOAD = 600 #/□"
f, COEFFICIENT OF FRICTION
PROJECTED AREA (Ld) IN²
ZNQ/1000P

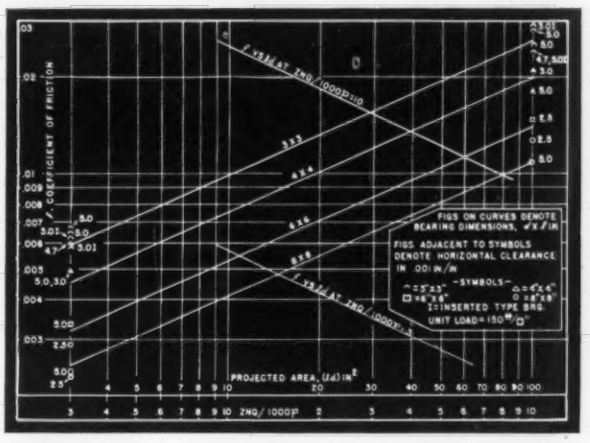
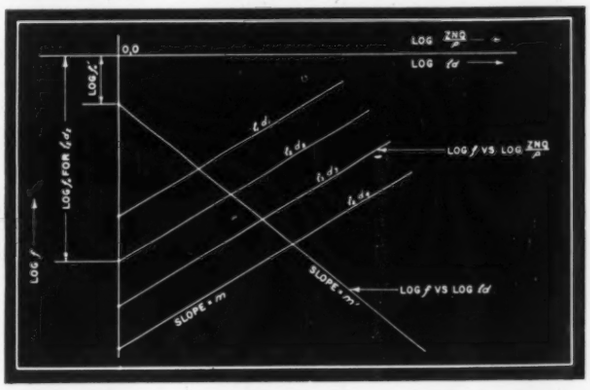

f COEFFICIENT OF FRICTION
PROJECTED AREA, (Ld) IN²
ZNQ/1000P
FIGS ON CURVES DENOTE BEARING DIMENSIONS, d" X l" IN
FIGS ADJACENT TO SYMBOLS DENOTE HORIZONTAL CLEARANCE IN .001 IN/IN
-SYMBOLS-
I=INSERTED TYPE BRG.
UNIT LOAD=150 #/□"

Fig. 8—Similar to Fig. 7, these curves show the effect of a load reduction to 150 pounds per square inch

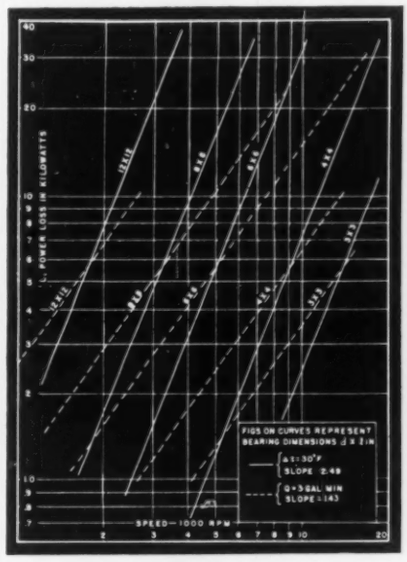
Fig. 9—These curves are used as the basis for the derivation of the power loss equation

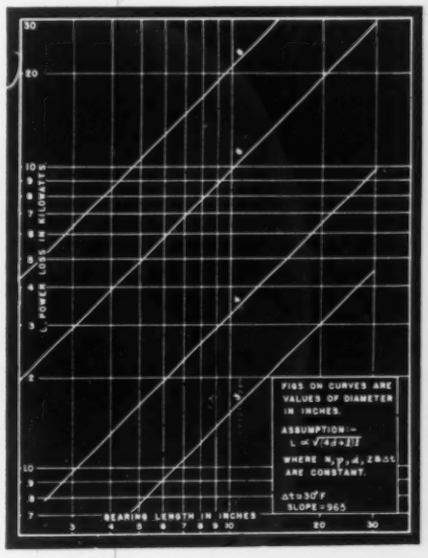


ficient. Ground and gritblasted surfaces with approximately the same profilometer reading all showed different load capacities. In such cases, other quantities or numbers are needed to describe a surface adequately. This is not surprising since a surface profile in itself is not simple. A much better quantity to be measured, in addition to the root-mean-square roughness, would be the frequency with which irregularities occur. This is the quantity which differentiates a metal sprayed surface from a gritblasted surface of the same roughness reading. Since the first derivative of a sine curve involves the frequency as a factor an instrument which electrically averages and records the slope as well as the displacement of a surface would be an improvement in describing a surface.

Fig. 10 — Right — Effect of speed on bearing loss using 120-degree bearings loaded to 150 pounds per square inch. Viscosity is 13 centipoises

Fig. 11 — Extreme right — Curves show effect of bearing length on power loss




L, POWER LOSS IN KILOWATTS
BEARING LENGTH IN INCHES
FIGS ON CURVES ARE VALUES OF DIAMETER IN INCHES.
ASSUMPTION:-
WHERE N, p, d, Z & Δt ARE CONSTANT.
Δt=30°F
SLOPE=.965

Surface finishes produced in various ways having roughnesses ranging from 130 to 1 microinch, as measured by their root-mean-square deviations from a median plane, have little or no effect on the performance of a partial journal bearing while it is operating under hydrodynamic lubrication.

The lower limit of the region of hydrodynamic lubrication for a given journal bearing combination as indicated by the minimum in the friction coefficient curve is markedly dependent on the surface finish of the journal, the value of $(d/c)^2ZN/p$ at the minimum decreasing as the surface becomes smoother. This implies an increase in the load capacity of the bearing with increasing smoothness and emphasizes the great importance of reducing the surface roughness to less than 15 microinches at least.

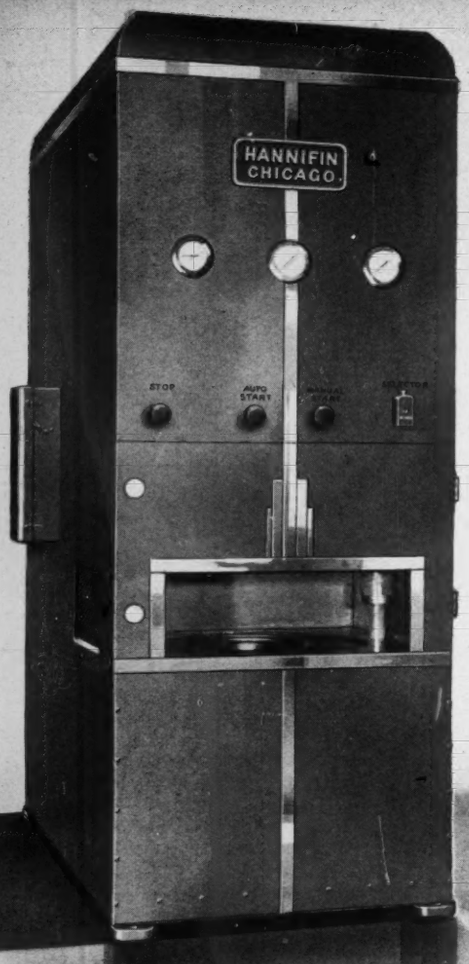
Bearing Lubrication*

Effect and inter-relationship of the various factors which influence bearing losses have been subjects of many experiments and a vast amount of theoretical work since the basic principles of hydrodynamic lubrication were outlined by Osborne Reynolds. In the half century following this work, this theory of lubrication has undergone considerable development. Like all theory, it needs to be examined and re-examined in the light of experimental data. In this paper, several novel contributions in the form of experiment and theory are presented. The paper deals with the results of tests made to determine the power losses of bearings of the type used on turbines manufactured by the company with which the authors are associated.

In the early part of the testing work, the flow of oil to the bearings was maintained constant so as to eliminate the effect of that variable, and it was found that, for each value of bearing pressure, the coefficient of friction varied exponentially with ZN/p; in other

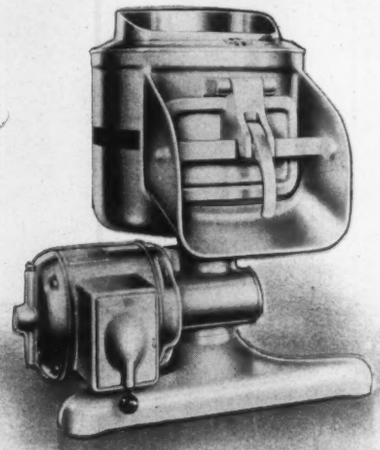
* Abstracted from a paper presented before a recent meeting of the A.S.M.E. by its authors, F. C. Linn and D. E. Irons of the General Electric Co.

(*Continued on Page* 106)



Hot wires and glow elements are eliminated in the Electromode heater (right) by design of the heating element, comprising aluminum cast and shrunk on a tube. Operating temperature is very low. Safety switch shuts off heat automatically if air flow is interrupted, while a separate fan switch permits running fan without heat in summer. Shaded-pole motor is in cool air stream

Split-phase splashproof motor in the Hobart peeler (below) drives the abrasive disk by a steel-bronze worm and gear reduction. All driven bearings have sealed-in lubrication. Abrasive of disk is cast directly into iron. Switch is drip-proof. Hopper is one-piece cast iron, with the inside ribbed vertically



Fixture for holding work in Hannifin centrifugal quenching machine (above) is surrounded by a circular quenching chamber which when closed permits simultaneous motor-driven rotation of the hot part, fixture and chamber. Oil is introduced at the outer edge of the container with controlled volume and temperature, and results in a revolving "doughnut" of oil around the circumference. Quenching action takes place toward the center

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Westinghouse turb comb
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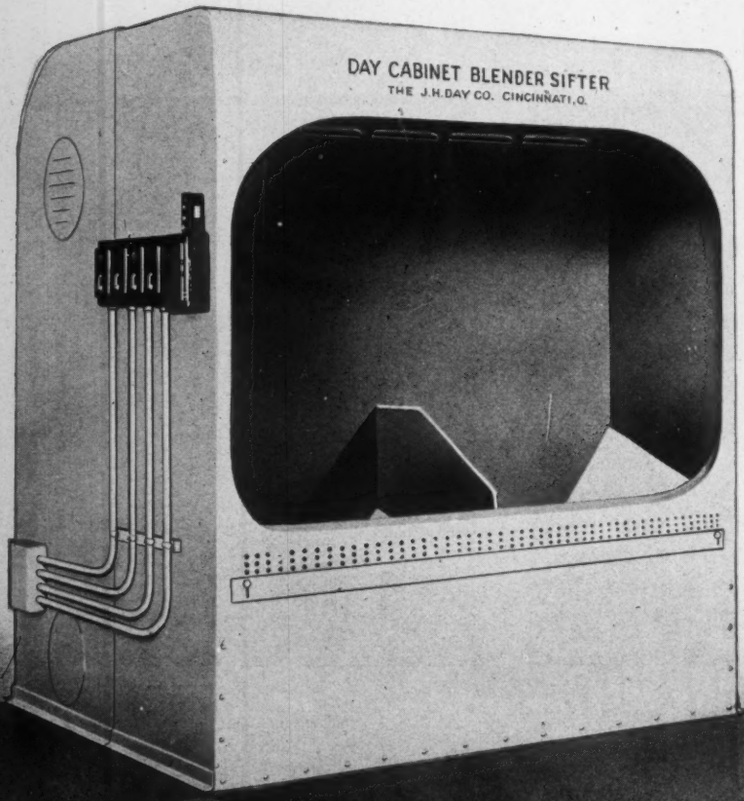


Five separate motors drive mechanisms in the Day cabinet blender (left). Four are inside the frame while fifth is outside and drives the conveyor and vertical elevator. A gyrating sifter utilizing ball cleaners permits use of a much finer screen cloth than usual. Slide type bearing on the sifter has a pivotal cast iron base while the upper part is a plastic compound impregnated with graphite

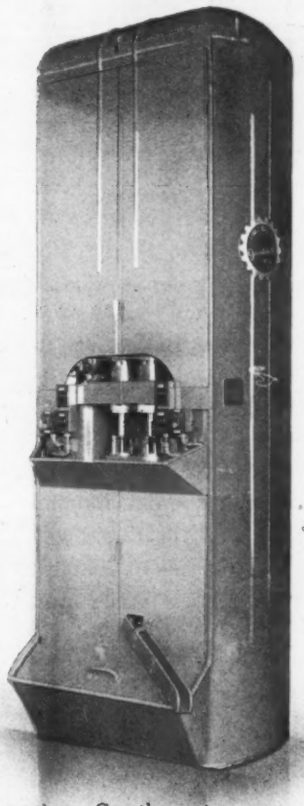
itchenAid mixer (below) was incorrectly esignated last month as the cover illustration, stead of the Landis shell tapper, described n Page 92 of this issue. The mixer has a niversal motor controlled in ten speeds by n electric governor, with direct drive. For omplete mixing, mixer travels around bowl one direction and turns on axis in opposite direction. Frame is zinc alloy die casting

Robotyper electric typewriter (above) utilizes a pneumatic system with aluminum valves to provide complete sealing. A roll of paper perforated like a player piano roll passes over a tracker bar, pneumatic valves being actuated and causing the type corresponding to that particular position on the bar to strike the paper. A selector device is also pneumatic and permits choosing any one of several letters on the roll. Specially built direct-drive motor is used

es Features E MACHINES

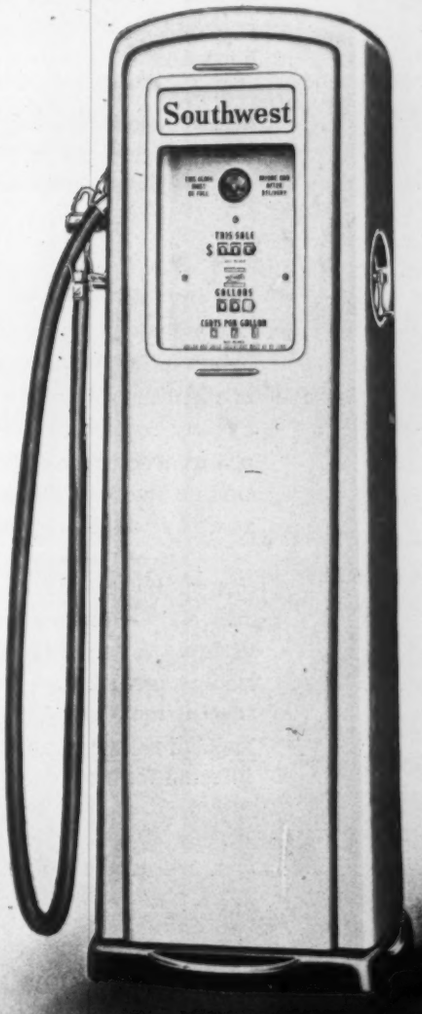
(For listing see page 114)

TH ER. Simple controls on the turb combine its operation with a sting sual processes of load control ine er regenerative or superposition. erlo perating nonextracting, an ad- s ar the governing system as a load- Stati ing is carried by separate rings erti orizontal centerlines and free to d in ons. In this way, minimum tip inta terials used in the high-pressure e ch olybdenum and tungsten alloys



Greater rigidity is provided in the American Gearbroacher (left) by a cylindrical welded steel column. Two hydraulic cylinders at the bottom are suspended from a steel work plate, this construction providing a free area without packing glands on the full area of the piston, eliminating packing leaks. Rear vertical portion of the machine houses the motor, hydraulic pumping equipment

Special valve in the Southwest pump (right) eliminates the vapor which accumulates because of agitation. All castings are chromium-nickel semi-steel, pistons and connecting rods of the meter are die-cast aluminum and valves are petroleum bronze. Radial meter has three horizontal pistons disposed at 120 degrees and connected to a free master journal. Inside pressure keeps pistons distended



Indirect built-in lighting illuminates panel of Hunter-Hartman Rocket battery servicer (left) and is controlled by panel switch. Synchronized time switch automatically shuts off charger after predetermined period. A protector switch cuts off charge when overloaded. Turret-top air duct cooling system draws air in consistent flow through top grill. Testing instruments are sealed in

MACHINE

Editorial

DESIGN

Now Is the Time To Give Designers the Tools They Need!

HOW many designers have wished, during development of a machine, they could see what was taking place within a faulty mechanism. How simple would seem the solution of the problem of a sticking part if only the interior of the unit could be disclosed to view. The stroboscope and the high-speed camera have been put to good use for observation of moving parts, viewed externally, but until recently nothing has been available to check the action of a hidden part in motion.

It seems that engineering research is likely once again to come to the aid of design. Recently developed is an X-ray device capable of taking photographs through or into operating structures at the phenomenal speed of a millionth of a second. Little stretch of the imagination is needed to visualize the far-reaching effect such equipment would have in the solution of some of the most disheartening problems confronting designers of machinery.

Engineering developments of this nature often are not given their rightful place in the field of design until years after they take place. An example of this is the photoelastic polariscope which only recently, after many years, is becoming recognized as one of the most important tools of design. Let us hope that with the speed now essential in the development of mechanical and armament equipment, ways and means will be found to place at the disposal of alert engineers the most up-to-date devices available to aid them in their work. Never has there been a more propitious time for such a program.

Motors in Machines

One of the most outstanding features of the application of individual motor drives in machines, as emphasized in articles on this form of drive published in MACHINE DESIGN during past years, is the ease with which changes in plant layout can be effected and the machines moved around. This is not by any means an everyday occurrence, but defense orders and consequent changeovers from normal to armament production have tended to focus attention on the need for flexibility in the location and use of available machinery, as well as on the desirability of ready introduction of new machines.

It is for this primary reason as well as to recognize the continued trend toward individual motorization of all types of machines, that MACHINE DESIGN has chosen for extensive coverage during 1941 the selection of motors in design. A series of articles on this subject, Part I of which appears as the leading contribution in this issue, is scheduled for publication over the next several months. The articles will discuss, in the main, the application of special rather than purely standard motors and consequently will present information not readily available elsewhere in the condensed form planned.

Professional Viewpoints

" . . . shot blasting may be harmful"

To the Editor:

Mr. Zimmerli is to be commended for his systematic and enlightening investigation concerning the improvement of fatigue strength in finished springs by shot-blasting methods as discussed in your November issue. Obtaining an increase in maximum stress of 42 per cent in one test will undoubtedly be of interest to designers, provided the blasted surface is not considered objectionable.

It must be recognized, however, that any attempt to improve fatigue properties by a mechanical method, such as shot blasting, may introduce a counteracting effect; namely, a lowering of fatigue strength by the formation of an irregular notched surface. Which of these opposed effects predominates will depend upon a number of factors involved in the blasting technique, some of which are the size, shape, and hardness of the blasting particle, and the velocity of impingement.

Not only is it possible for the fatigue strength to be influenced by the factors already mentioned, but it may be lowered considerably by embrittlement of the surface due to excessive shot blasting. It is difficult to separate the influence on fatigue properties of surface embrittlement and of notch effect introduced by shot blasting, but it appears that both effects can be mitigated by the use of proper blasting technique. Moreover, surface embrittlement, if present, may be eliminated by appropriate heat treatment.

—GEORGE L. KEHL
U. S. Steel Corp.

" . . . stimulates interest in hydraulics"

To the Editor:

I have read with interest the leading article in your December issue, "Hydraulic Control Affords Design Flexibility," as prepared by Christian E. Grosser. Although this article is elementary and does not delve into the engineering details involved in the various applications described, I believe it will stimulate further interest in the application of fluid power and prove of value in assisting the many users in the selection of the type of equipment which will prove most feasible.

Sometime in the near future I hope that one or more outstanding hydraulic engineers or professors of mechanical engineering will undertake to discuss in detail one or more of the many conventional applications of fluid power and then elaborate upon the determining factors involved in selecting specific fluid power equipment to make possible the ultimate in design with present-day materials and facilities. Although this assignment would require considerable deliberation I believe it would be a major step toward the compilation of facts to provide a more comprehensive view of the possibilities or limitations of fluid power.

—M. E. ENGEBRETSON
The Oilgear Co.

The article referred to above is purposely elementary in nature. It is the introductory article in a series to be presented by Mr. Grosser. The subjects suggested by Mr. Engebretson will be covered as far as practicable in subsequent articles.—ED.

" . . . would like reprints"

To the Editor:

We have had several requests for reprints of a series of articles that appeared in MACHINE DESIGN. The title is "Photoelastic Analysis in Commercial Practice," by R. E. Orton of the Acme Steel Company.

Do you have reprints available? If it is impossible to get them would you kindly allow us to have the articles photostated?

—I. STROBACH, Librarian
Western Electric Co.

To the Editor:

I would like to praise your excellent choice both as to the idea and text of the recent series of five articles by R. E. Orton on "Photoelastic Analysis in Commercial Practice." As a design engineer I greatly enjoyed the series and benefitted by it. I would like to request a reprint of the series.

—CARL A. FEICHTINGER
St. Louis, Missouri

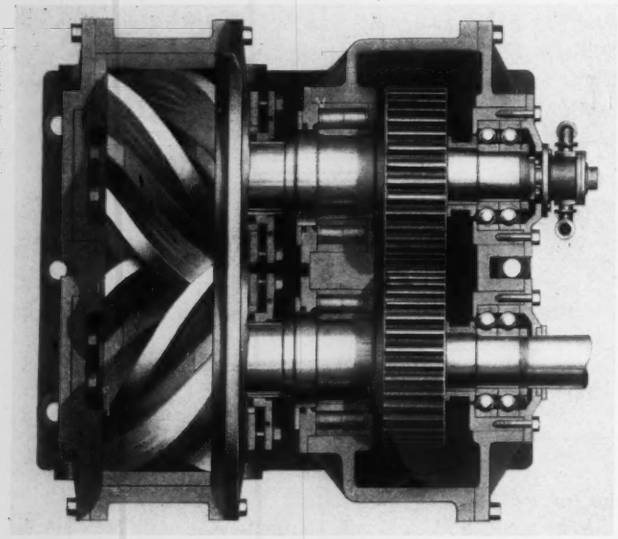
Reprints are now available and will be sent gladly to readers upon request as long as the supply lasts.—ED.

Applications
of Engineering Parts and Materials

Timing Gears Carry Impeller Load

HARDENED and heat treated alloy steel timing gears insure long life of this pump by obviating the necessity of mechanical power transmission between the rotors. Intended for use as cargo pumps in ship to shore liquid transfer service, the solid type roller bearings adjacent the pump chamber and the duplex, preloaded ball bearings at the coupling end maintain accurate relationship of the rotors regardless of the position of the ship.

Designed by the Kinney Manufacturing Co., the pump, by reason of its five helical impellers on each rotor, eliminates all fluid pulsation which would result in costly pipe line maintenance. Since it will operate under high vacuum heads, the pump will handle mixtures of air, gas and liquid without priming and without auxiliary stripping pumps.

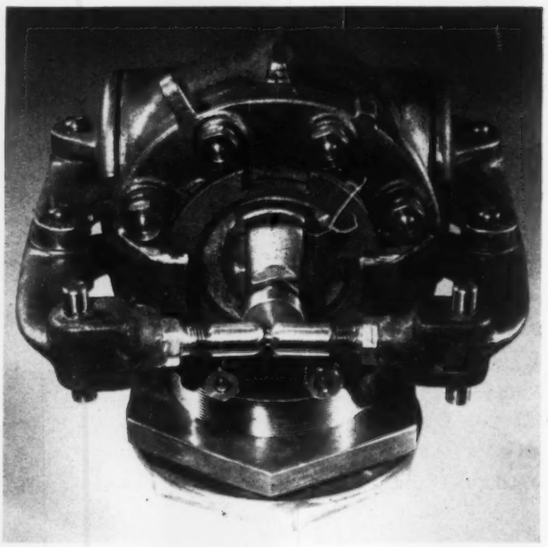


Preloaded ball and radial roller bearings supplement the hardened steel timing gears in eliminating all driving load from impellers

Valve Affords Triple Protection

THREE separate relief valve functions are combined into one unit operated by a single diaphragm in the control illustrated. Designed primarily to protect glass lined vessels from pressure overloading, the valve should have many applications on low pressure vessels where this three-way protection is necessary. The diaphragm, working through the mechanical linkages shown in the accompanying illustration protects the tank from excessive gas pressures above the contained liquid; from excessive liquid heads in the vessel and also from any tendency to collapse the tank as a result of vacuum.

Manufactured by the Pfaudler Co., the gas and liquid blow-off pressures are adjustable by means of socket screws. The vacuum relief is permanently set to open at a vacuum of approximately three inches.



Valve protects low pressure vessels from excessive pressure, vacuum and liquid heads

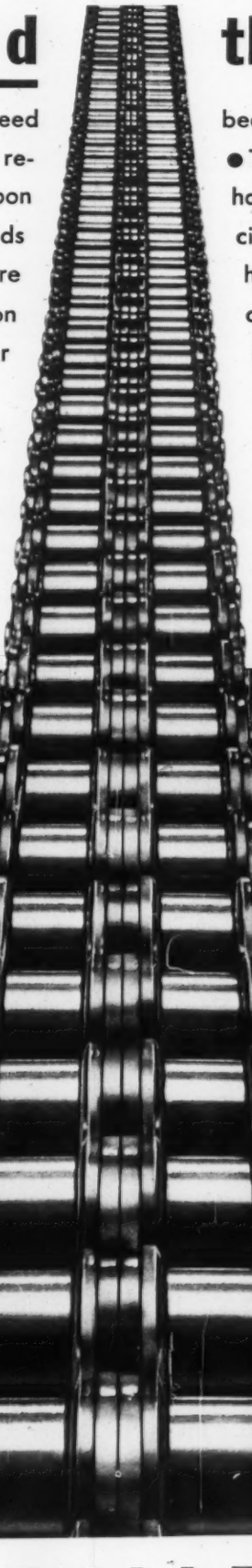
Lever Has Reduced Inertia

BERYLLIUM copper cast and heat treated to a hardness of 40 Rockwell C solved the materials problem of the illustrated switch lever and latch for the indexing mechanism of automatic screw machines.

Appreciable weight reduction was achieved with consequent reduced inertia over the next most satisfactory material (chromium plated cast steel).

Beryllium copper used in this cam lever combines strength and hardness with light weight

To Increase Production Output and Hold the Increase

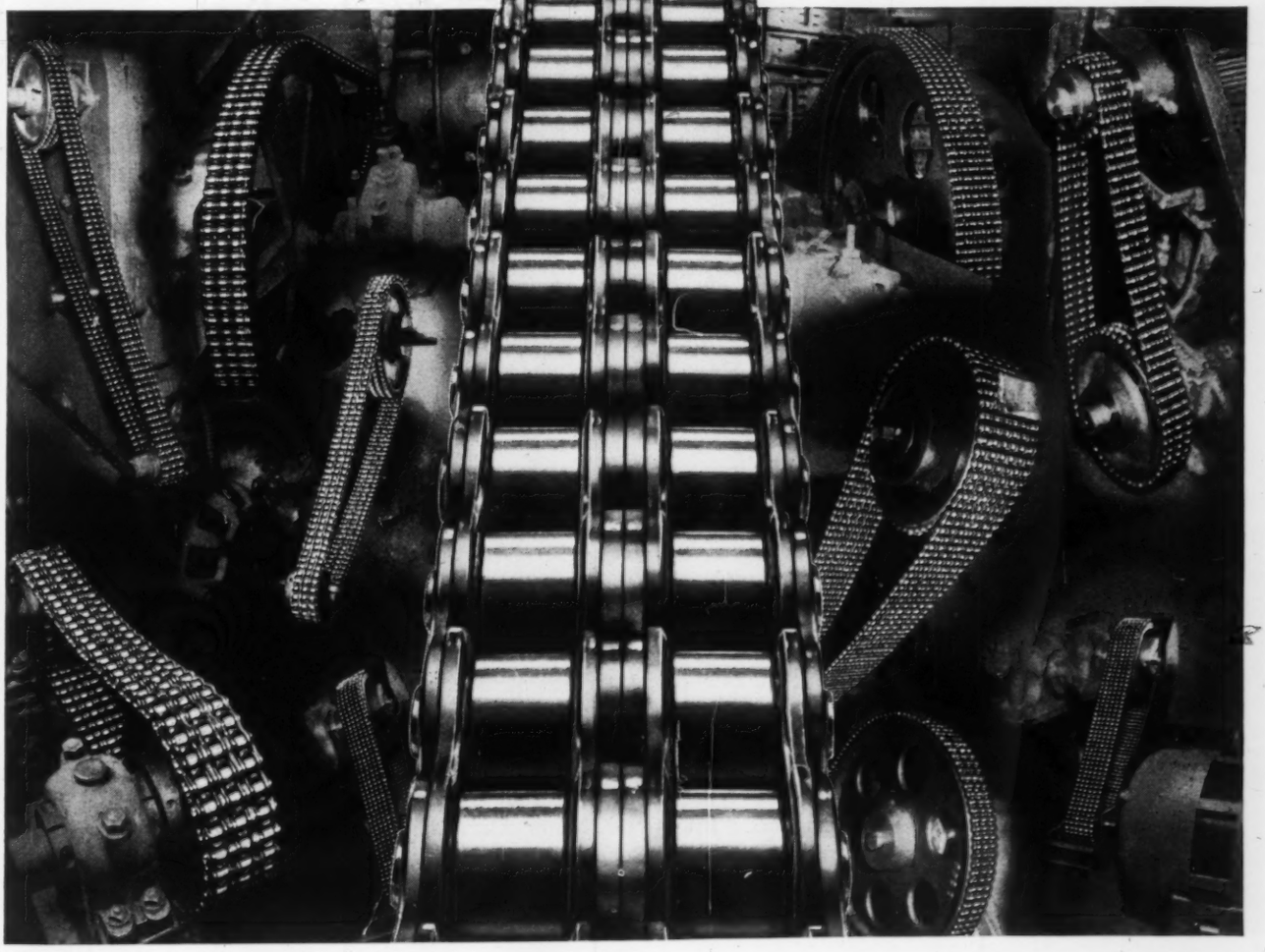


● Drives that slip or creep, that need frequent adjustments, tightening or replacements cannot be depended upon for maximum production. But thousands of manufacturing men know that there is a proved way to get top production output . . . with DIAMOND Roller Chain Motor Drives.

● DIAMOND Drives do not slip or creep—they keep producing machinery at the top speed needed for maximum output. Not being dependent on friction, they are easy on bearings and thus reduce bearing wear.

● The motor drives for which industry has selected DIAMOND range in capacities from a fraction to a thousand horsepower—with as many as 8000 drives in a single plant . . . If you are interested in improving output and holding this increase, make your next drives DIAMOND Roller Chain (anti-friction) Drives. DIAMOND CHAIN & MFG. CO., 435 Kentucky Ave., Indianapolis, Ind. Offices and Distributors in All Principal Cities.

50th Anniversary 1890-1940



DIAMOND ROLLER CHAINS

Men of Machines

A. H. WILLIAMS

CONNECTED with the Shafer Bearing Corp. since 1923, A. H. Williams has been appointed vice president in charge of engineering. Upon graduation from the University of Minnesota, Mr. Williams' first position was in the research department of Studebaker Corp., developing improvements in carburetion, manifolding and combustion chambers as well as conducting tests on antifriction bearings. A year later he assisted in the development of the Chrysler car. As a result of his previous research on bearings, he became associated with Shafer Bearing Corp., taking charge of heat treatment and inspection. In a year he assumed the duties of chief engineer, and in addition to making improvements in the Shafer bearing and manufacturing process, he was instrumental in developing a complete line of roller bearing unit mountings. In 1935 he resigned to join Cleveland Automatic Machine Co. as general superintendent, and in a year and a half returned to Shafer.

C. E. HARRISON

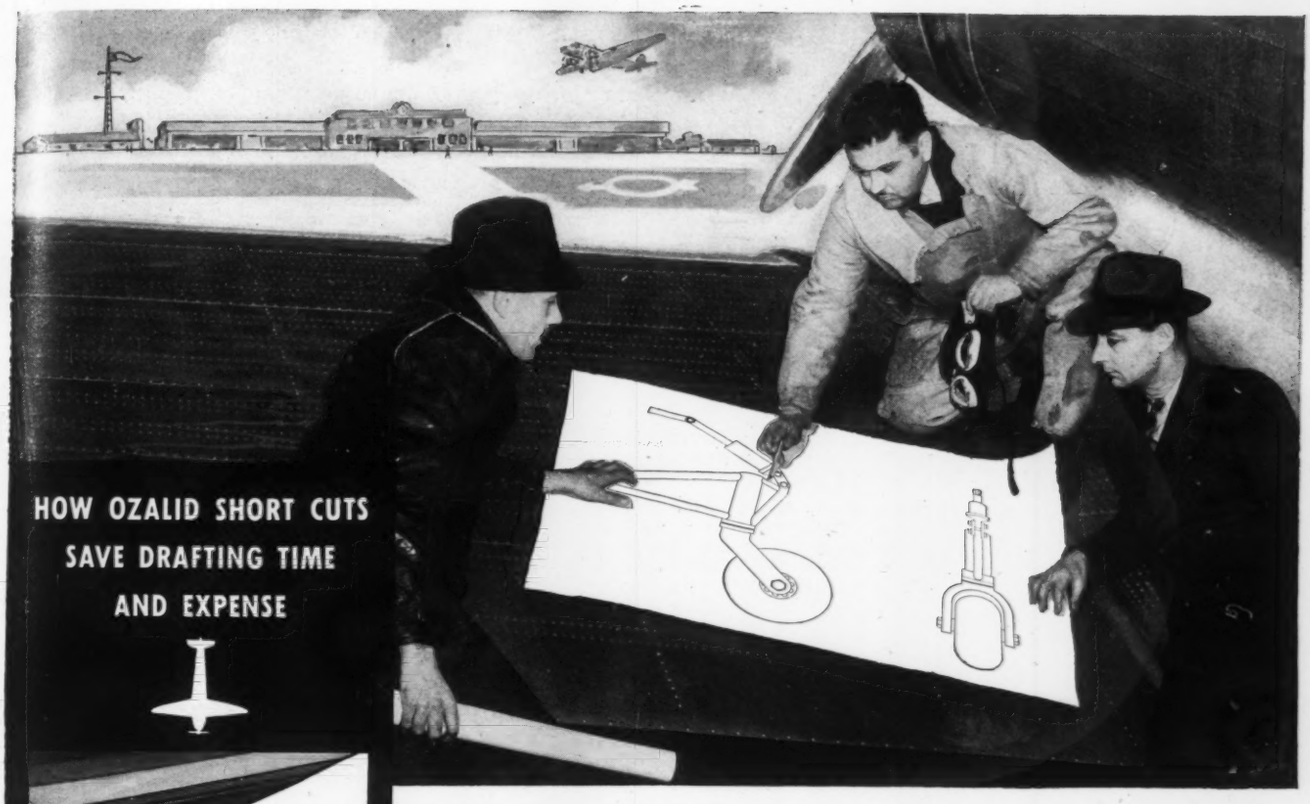
HAVING taken an active part in the design and development work of American Engineering Co., C. E. Harrison has recently undertaken his new duties as general manager. He has supervision of the entire activities of the company in addition to his duties as vice president.

Mr. Harrison, a mechanical engineer, served in the U. S. Navy before becoming associated with American Engineering Co. as field engineer. In 1936 he was made works manager, and in two years elevated to the vice presidency. As a result of his design and development activities he has been granted fifty patents in the United States and foreign countries. Much of his attention has been devoted to utilization of directed air flow in design of combustion equipment as a means of increasing efficiency in the combustion process and of prolonging the life of furnace parts in general. He has also spent considerable time on standardization which has resulted in elimination of many parts and in simplification of design.

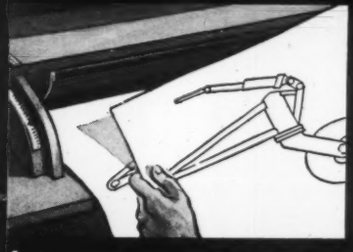
J. F. DOWNIE SMITH

OPPORTUNITIES flow toward J. F. Downie Smith, the latest being that of becoming a member of the research staff of United Shoe Machinery Corp. He recently resigned as executive engineer of research and development of E. G. Budd Mfg. Co. Previous design activities include developments in automobile engines, candy machines, hydraulic presses, machine tools, air conditioning systems, railcars, sound proofing, application of rubber and plastics, heat transfer equipment and flow meters.

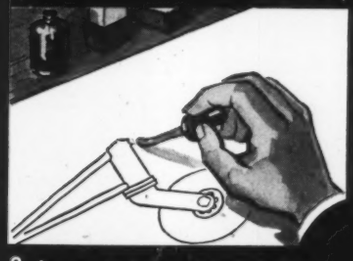
Dr. Downie Smith's first position after graduating was that of apprentice, later machine and tool designer, with Albion Motor Car Co., Glasgow, where he served for six years. At Georgia School of Technology he was assistant professor of experimental engineering for two years, and later for two years was assistant professor of engineering drawing at the Virginia Polytechnic institute. After spending eight years with the Harvard Graduate School of Engineering as National Research Fellow,



HOW OZALID SHORT CUTS SAVE DRAFTING TIME AND EXPENSE



1. An Ozalid paper, cloth, or foil transparent duplicate is printed and developed dry in the same simple manner as standard Ozalid whiteprints.



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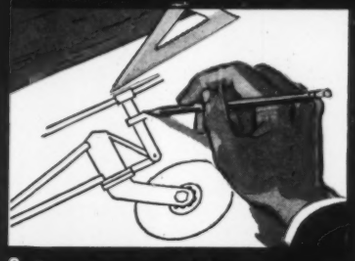

3. Corrections can be drawn in on the transparent duplicate in either pencil or ink. Prints made from the altered transparent duplicate include all changes. The original drawing remains unchanged.

NEW SPEED IN DESIGN CHANGES WITH Ozalid TRANSPARENT DUPLICATES

Industrial production zooms and drafting and design departments become jammed with work. Skilled machinists are scarce; good mechanical draftsmen scarcer. But undermanned and overworked drafting departments get a blood transfusion when they adopt the Ozalid Process.

No more difficult and exacting overlays—no more tedious and wasteful redrawing when Ozalid transparent duplicates are used. Delete that part of the design you don't want; add details in pencil or ink. Whole sections dropped out or just a few lines changed, it is all the same when reworking an Ozalid transparent duplicate.

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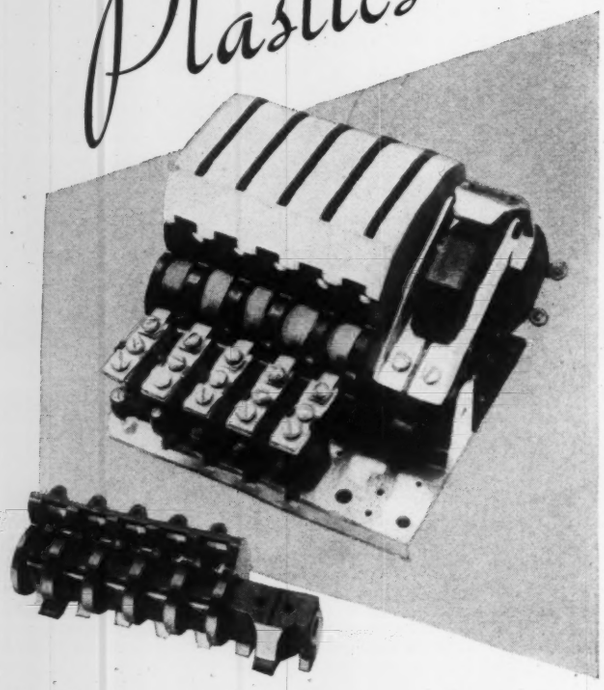
Plastics



MOLDED SHAFT
combines 8 parts and functions in single piece

★ One of General Electric's five top award winners in the recent Modern Plastics Competition was a molded Textolite contactor shaft which incorporates the following 8 parts and functions in a single piece of material:

1. Bearings on which to rotate an assembly of parts.
2. Support for magnet armature.
3. Individual bearing, stop, guides and barriers for each of five contact tips.
4. Guides and barriers for each of five flexible braid connectors.
5. Spring seats for each of five movable contact tips.
6. Molded arms with which to operate up to seven auxiliary switches that may be used in the final application.
7. Molded arms with which to operate mechanical interlocks.
8. Complete high quality insulation for all of the above parts.

★ Because the shaft is a single piece of mater.al, the possibility of loosening of parts is eliminated, making for permanent maintenance of factory adjustment and long life. Because the material is in itself high quality insulation, it permits the closest possible spacing of the parts that must be alive, such as contact fingers, terminals and connectors. The Textolite material also adds to the life of the main bearings, and makes them free from corrosion or lubrication troubles.

For a free copy of our new booklet "One Plastics Avenue," write Section B-15, Plastics Department, General Electric Co., One Plastics Avenue, Pittsfield, Mass.

PLASTICS DEPARTMENT
PD-152

GENERAL ELECTRIC

assistant and faculty instructor in mechanical engineering, he joined the E. G. Budd Mfg. Co. and remained there until his present appointment. Recently he was made vice chairman of the Subdivision on Rubber and Plastics of the American Society of Mechanical Engineers. He also is a member of the A. S. M. E. Power Test Codes on Displacement Compressors and Blowers, and the Committee on Thermo-Physical Properties.

♦

THOMAS GERLACH has been transferred to the Detroit office of Aviation Mfg. Corp., Williamsport, Pa., where he will be associated with PETER ALTMAN whose connection with the company's research and development division was announced recently. Mr. Altman resigned as director of the department of aeronautical engineering at the University of Detroit, while Mr. Gerlach was previously executive engineer with the Aviation company. WILLIAM F. WISE has been made executive vice president of the Aviation Mfg. Corp.

♦

CHARLES F. KETTERING of Detroit received the American Society of Mechanical Engineers medal for outstanding inventions and research. The Junior A.S.M.E. award was presented to ROBERT E. NEWTON of St. Louis, for his paper "A Photoelastic Study of Stresses in Rotary Disks."

♦

H. V. PUTMAN, who has been manager of engineering at the Sharon, Pa., transformer works of Westinghouse Electric & Mfg. Co. since 1931, has been transferred to the Pittsburgh headquarters of the company as staff assistant to the general works manager. Since joining Westinghouse in 1925 Mr. Putman's duties have been those of design engineer on synchronous motors, section engineer in charge of synchronous motor design and assistant manager of the transformer division engineering department. He developed the company's first completely fabricated line of synchronous motors.

♦

CARL A. W. BRANDT, chief engineer of The Superheater Co., New York, has received the Melville medal for original engineering work, which was presented to him by the American Society of Mechanical Engineers.

♦

CLARENCE L. TAYLOR has been elected vice president in charge of engineering, Arms-Franklin Corp., Franklin, Pa., designers and builders of steel mill equipment. Mr. Taylor was formerly vice president in charge of engineering at Aetna-Standard Engineering Co.

♦

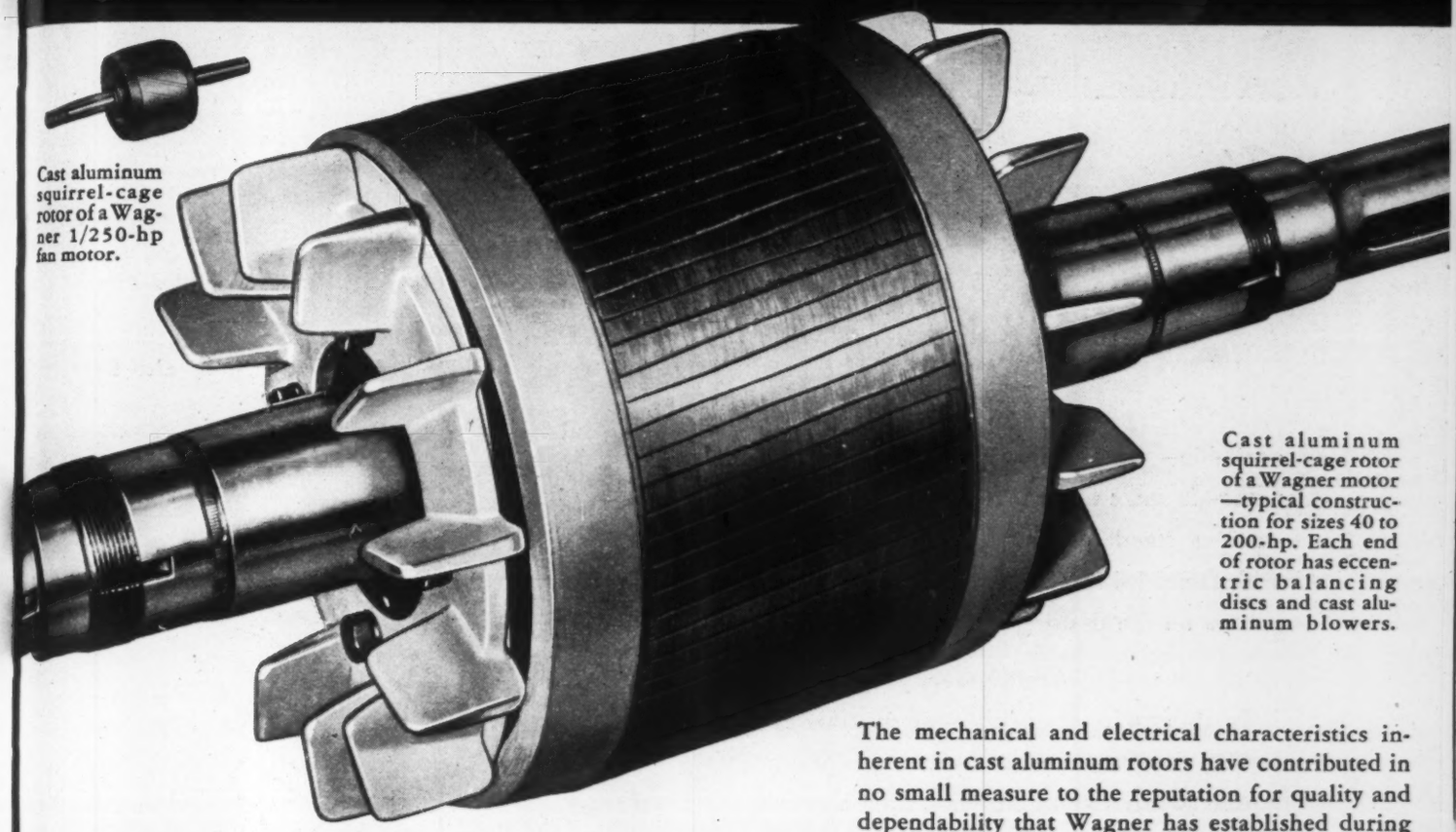
R. E. DOHERTY, president, Carnegie Institute of Technology, has been elected chairman of the Engineers' Council for Professional Development, and HARRY T. WOOLSON, executive engineer, the Chrysler Corp., becomes vice chairman.

♦

OLIVER SMALLEY, president, Meehanite Metal Corp., Pittsburgh, was recently re-elected president, Meehanite Research Institute of America Inc.

Hundreds of Thousands of WAGNER MOTORS with Cast Aluminum Rotors

have been built during the past 20 Years and are still giving perfect satisfaction!



Cast aluminum squirrel-cage rotor of a Wagner 1/250-hp fan motor.

Cast aluminum squirrel-cage rotor of a Wagner motor—typical construction for sizes 40 to 200-hp. Each end of rotor has eccentric balancing discs and cast aluminum blowers.

The mechanical and electrical characteristics inherent in cast aluminum rotors have contributed in no small measure to the reputation for quality and dependability that Wagner has established during the past 50 years.

Some of the advantages of cast aluminum construction are:

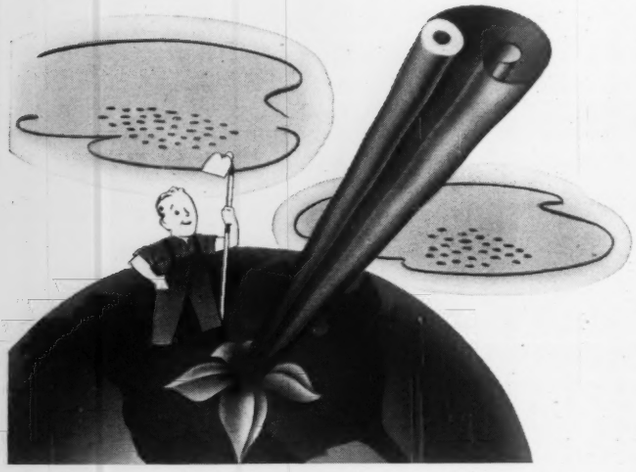
1. The squirrel-cage is cast under heavy pressure, completely filling the closed rotor slots and the moulds which form the end-rings.
2. The rotor bars and end-rings make complete and intimate contact with the core iron, facilitating heat transfer and absolutely eliminating squirrel-cage vibration.
3. The squirrel-cage material in general-purpose motors is practically pure aluminum of high conductivity and ductility. The most severe service does not make it brittle.
4. A special patented construction is used in the larger sizes, resulting in reduced load losses and increased motor efficiency.

Wagner Uses Cast Aluminum Squirrel-Cage Rotors From 8-Inch Fans to 200-hp Motors

Wagner Electric Corporation

6400 Plymouth Avenue, Saint Louis, Mo., U.S.A.

MOTORS • TRANSFORMERS • FANS • BRAKES



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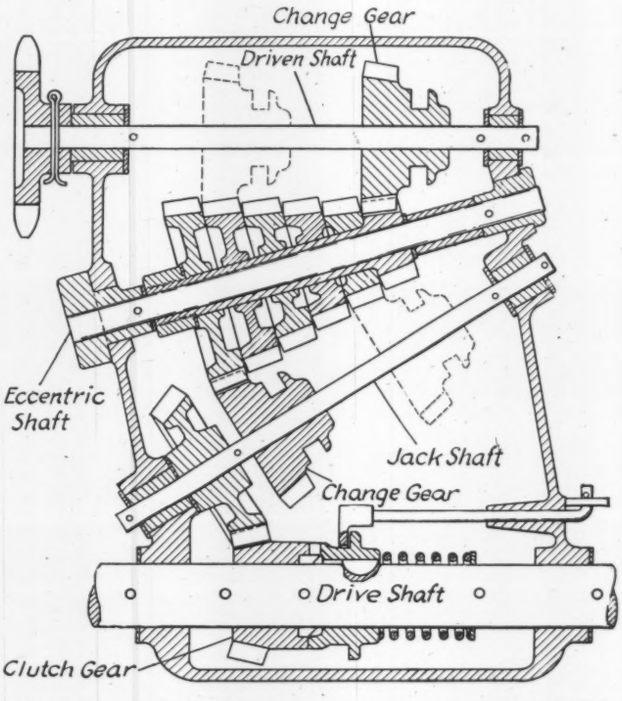
Noteworthy PATENTS

Ten Gears Provide Thirty-Six Speeds

PRIMARILY designed for use on a grain drill, this transmission should have many applications where compactness combined with a large number of speed changes is desirable.

Power from the prime mover is supplied through the drive shaft which operates the jack shaft through a pair of bevel gears. Splined to the jack shaft is a change gear. This gear is capable of being engaged with any one of the six gears mounted rigidly on the sleeve bushing which is free on the eccentric shaft. A second change gear, shown mounted on the upper shaft of the illustration, may also be



Wide range of speed-torque ratios is possible with this compact and inexpensive transmission

engaged with any one of these six gears. Both of the change gears are provided with grooves to accommodate shifting forks by which they are operated externally to the housing.

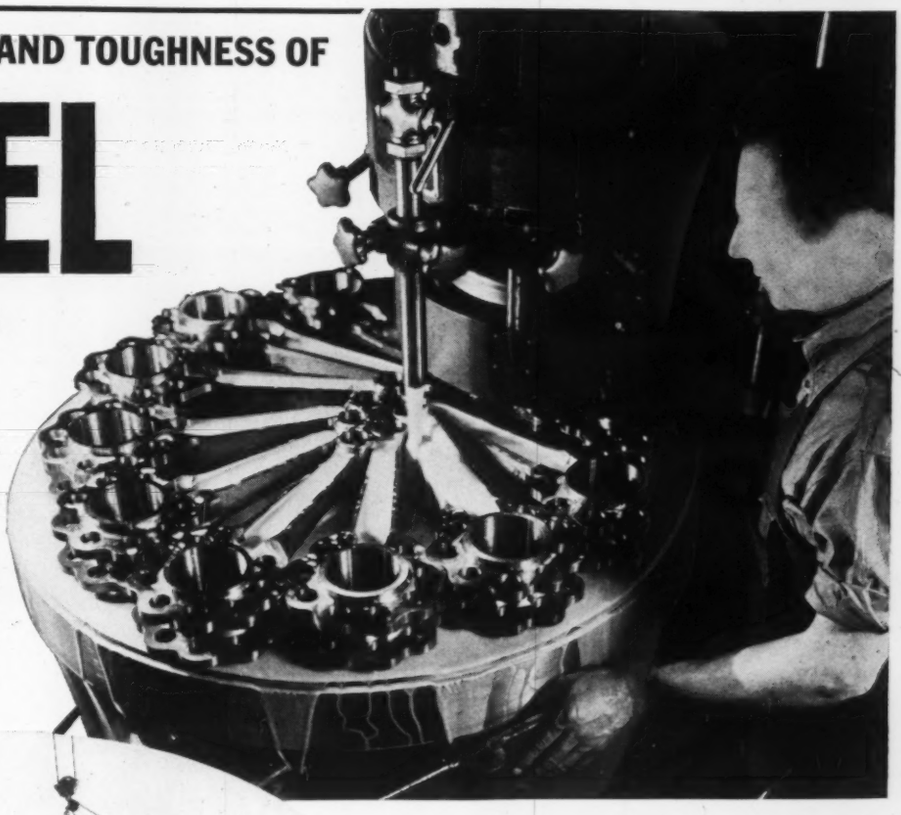
In order to make possible the shifting of the gears, the eccentric shaft is so mounted in eccentric bushings carried in the housing that when rotated by means of a handle which may be attached to a flange

Safe DEFENSE against breakdowns . . .

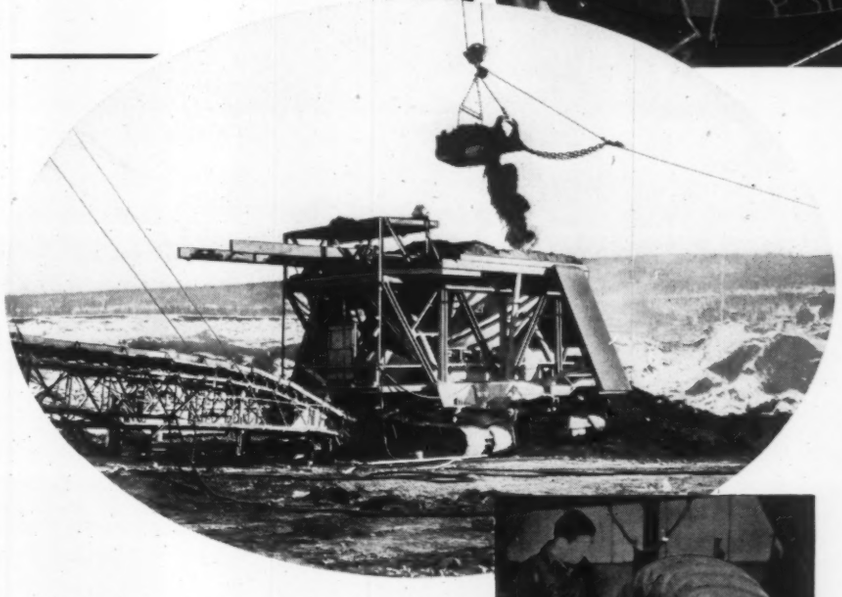
INCREASED STRENGTH AND TOUGHNESS OF

NICKEL

ALLOY STEELS



NEW JERSEY—Compactness, light weight, high strength and fatigue resistance are life-and-death requirements for aircraft engine parts. Here you see connecting rods of Nickel-chromium-molybdenum steel machined at the Paterson, New Jersey, plant of WRIGHT AERONAUTICAL CORP. Through their uniform response to heat treatment and ready machinability at high hardness, Nickel alloy steels simplify production.



ALASKA—Stripping 60 million cubic yards of frozen soil from 16 million cubic yards of gold bearing gravel is the job of this Bucyrus-Monighan electric drag line and BUCYRUS-ERIE traveling feeder. Working near Fairbanks, Alaska—more than 2,000 miles away from replacement parts—embrittlement and breakage at subzero temperatures must be avoided. More than 17 tons of 3½% Nickel low carbon steel forgings were used, chiefly for shafting. Three tons of 1.50/2.00% Nickel steel castings are also employed. Gears, pinions and crawler parts are heat-treated Nickel-chromium steel. The mile long conveyor belt system, furnished by the PACIFIC CAR & FOUNDRY CO., depends on speed reducer shafts of tough Nickel-chromium-molybdenum steel, SAE 4340.

NEW YORK—Cost records show this power-driven INGERSOLL-RAND Impact Wrench 6 to 8 times faster and more efficient than hand methods for applying and removing nuts. The hammers and anvils which withstand up to 1100 torsional impacts per minute are Nickel-chromium-molybdenum steel. Nickel alloy steel is readily hardened to prevent battering and stoutly resists wear and fatigue.

• • •

AVOID BREAKDOWNS and costly delays by specifying new equipment and replacement parts in tough, shock-resisting Nickel alloy steels. For practical information about recommended applications of Nickel alloyed materials, please address:

THE INTERNATIONAL NICKEL COMPANY, INC. **67 WALL STREET NEW YORK, N. Y.**

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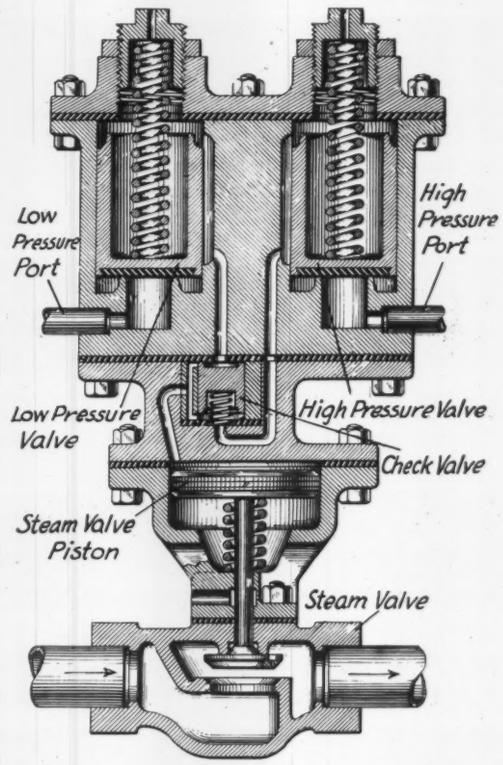
on one of the bushings, the six gears are rotated out of engagement with both of the change gears. A gear clutch mounted on the drive shaft permits disengagement of the assembly from the prime mover if desired. This transmission, the patent for which is assigned to the Massey-Harris Co., provides a total of thirty-six gear changes using only ten gears.

Pressure Limits Compressor Operation

DUAL control of steam supplied to a compressor which provides compressed air to locomotive air brake systems is achieved by the illustrated governor, the patent for which is assigned to the Westinghouse Air Brake Co. The low pressure valve maintains a predetermined pressure in the air reservoir while the brakes are in the released position. When the brakes are applied, the high pressure valve serves to maintain a high pressure in the system.

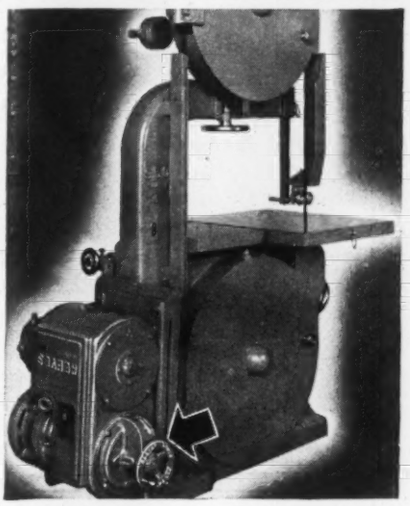
Normally the steam valve is open and the compressor is in operation. When the air pressure reaches the control point for the low pressure valve, the valve is lifted slightly off its seat against the closing spring. As soon as this occurs the pressure acts against the whole area of the low pressure valve piston thus opening wide the valve and causing the upper end of the piston to seat, sealing off the atmospheric vent. Air then flows through the escape passage, opens the check valve and flows to the top side of the steam valve piston, thereby closing the steam valve and preventing further pressure increase.



High and low air pressure levels are maintained by on-off control of steam used to operate the compressor

When the brakes are applied, the low pressure port

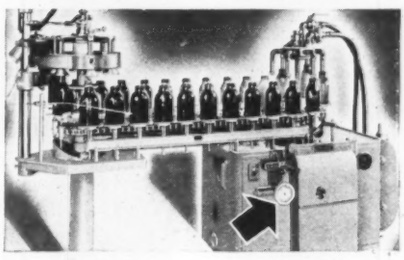
What's New—
IN SPEED CONTROL APPLICATIONS



ON METAL BAND SAW

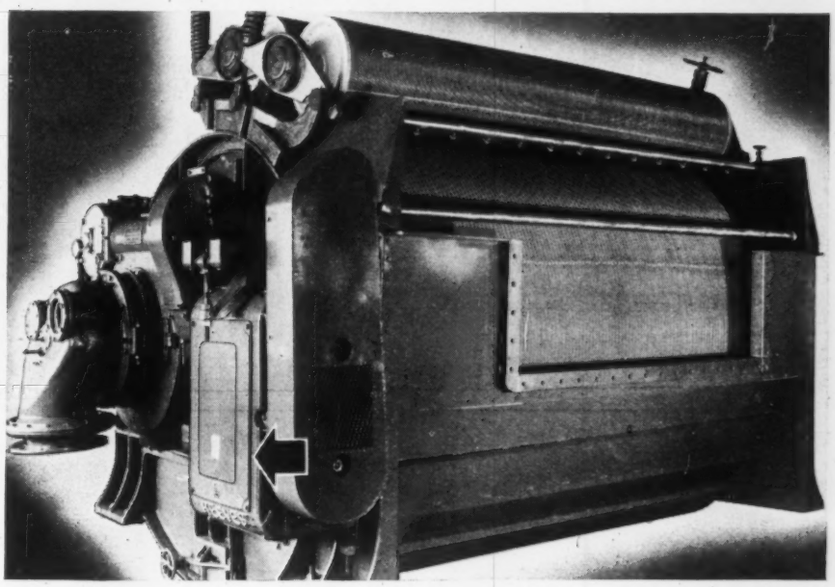
Blade speeds on this new Fay & Egan heavy duty metal cutting band saw can be varied from 80 to 960 f.p.m. or 350 to 1050 f.p.m. according to thickness of cut and hardness of metal. This stepless speed adjustability is provided by REEVES motodrive which combines constant speed motor, speed varying mechanism and speed reducer (if required) in one compact enclosure.

ON BOTTLE FILLER



Installed within the cabinet of the above bottle filler manufactured by Karl Kiefer Machine Co., are a REEVES Transmission and a Vari-speed Motor Pulley which synchronize speed of container travel with speed at which product flows from the filler.

SPEED CONTROL ON WASHER-THICKENER

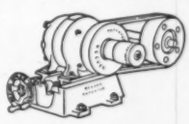


A six-to-one ratio horizontal enclosed REEVES Transmission is mounted vertically on this "Impco" Rotary Vacuum Washer-Thickener manufactured by the Improved Paper Machinery Corporation, Nashua, N. H., to regulate the capacity for handling paper pulp stock at varying dilutions and tonnages. A pivoting motor base is mounted on the end of the Transmission to provide compact drive to the constant speed input to the Transmission and from variable speed shaft to Filter.

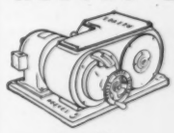
● Each of the machines pictured here is a more efficient production unit because of accurate variable speed control. Each has the proper variable speed drive—chosen from the wide range of designs, sizes, speed ratios and controls in the complete REEVES line. Let REEVES engineers recommend how this time-tested speed adjustability can be incorporated in the machines you build. Nation-wide service insures prompt action on your requirements.

THE 3 BASIC UNITS IN MODERN REEVES LINE

Transmission



Motor Pulley



Motodrive

REEVES ACCURATE POSITIVE SPEED CONTROL

REEVES PULLEY CO., Dept. H,
Columbus, Indiana

Send copy of 124-page Catalog-Manual describing REEVES Speed Control units and how they are being used as standard equipment on 1,376 different makes of machines.

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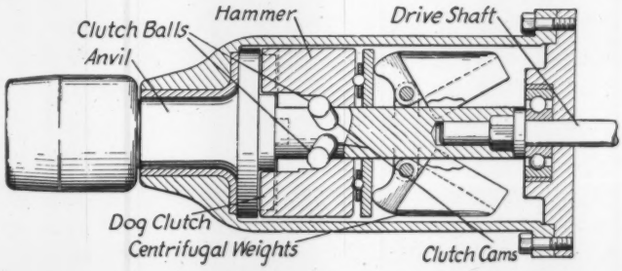
is disconnected from the reservoir. The high pressure valve which is permanently connected with the reservoir permits a higher pressure to be built up, because of its heavier spring, before the steam valve is closed. This valve operates in exactly the same manner as the low pressure valve. The check valve serves to isolate the two valves from each other.

Centrifugal Weights Limit Torque

CENTRIFUGAL weights opposed on a drive spindle control the hammer operation of this impact wrench through a pair of ball cam-clutches. Dog clutch teeth are formed on the adjacent surfaces of the hammer and the anvil. The latter carries a socket wrench. The power source, usually an electric motor, is direct connected to the drive shaft on the right side of the illustration.

Since the centers of gravity of the centrifugal weights are located in a plane normal to the axis of the shaft and to the right of the hinge pins, rotation of the shaft results in an axial thrust on



Clutch-cams rotate the hammer and provide for its axial movement in this impact wrench

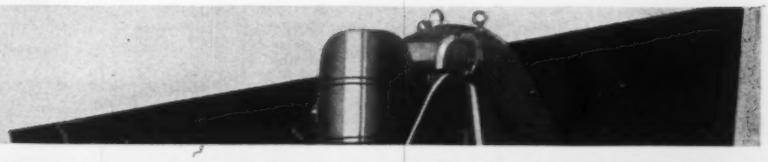
the hammer, maintaining the dog clutch in engagement and turning the wrench with a predetermined torque.

Shown in this position, each clutch ball rests in the apex of a V-shaped recess in the spindle and also in a similar recess in the hammer. As resistance to rotation of the wrench increases, the reaction in the ball clutch-cam draws the hammer to the right, disengaging the dog clutch. This withdrawal pivots the centrifugal weights about their hinge pins. The resultant shortening of the radius of gyration restores some of the energy of the weights to the spindle and also increases the effective moment arms of the centers of gravity about the hinge pins. Consequently the thrust of the weights against the hammer increases and re-engages the dog clutch, thus delivering a torque impact to the wrench.

In this wrench, the patent for which is assigned to the Chicago Pneumatic Tool Co., helical or compression springs used in conventional impact devices are rendered unnecessary by the contour of the clutch-cam recesses.

Inertia Controls Clutch Engagement

SYNCHRONIZATION of the speed of a driven shaft in a transmission with that of a drive shaft before positive gear engagement is controlled by inertia oper-

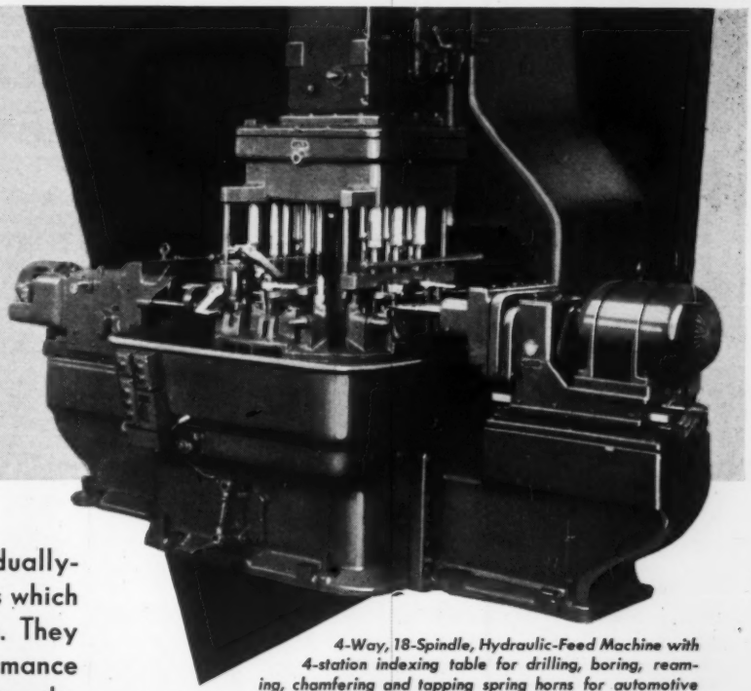


MODERNIZE YOUR FACTORY EQUIPMENT

Dynamically Balanced

DELCO

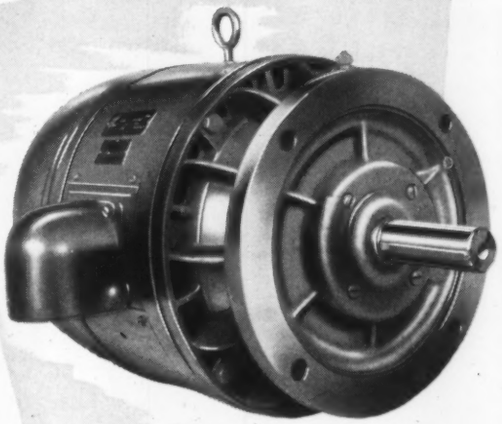
Motors



4-Way, 18-Spindle, Hydraulic-Feed Machine with 4-station indexing table for drilling, boring, reaming, chamfering and tapping spring horns for automotive assembly. Driven by four dynamically balanced Delco motors . . . three constant-speed, and the other reversing-type.

In replacing old equipment with individually-driven machines, consider the advantages which Delco motors offer in these applications. They are specific advantages, proved by performance records in large automotive factories during the past several years.

Particularly important among the characteristics which qualify Delco motors for this job is their exceptional *freedom from vibration*. This is attained by Delco Products' accurate dynamic-balancing operation, developed by General Motors and Delco Products engineers, and applied to Delco motors of all types and sizes.



Totally-enclosed, fan-cooled, ball-bearing Delco motor—flange-mounted.

Perfect alignment, maintained throughout production, and accurate machining of shaft and bearing surfaces are other contributing factors to the long, satisfactory operation of Delco motors on industrial machines.

For longer machine life, quieter operation, and more accurate machining operations as a result of reduced vibration, specify Delco motors. The Delco Products Engineering Department will make specific recommendations on request.

DELCO MOTORS

DIVISION OF GENERAL MOTORS CORPORATION

DELCO PRODUCTS DAYTON, OHIO

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QUALITY

SERVICE

RIGHT PRICES

COURTEOUS

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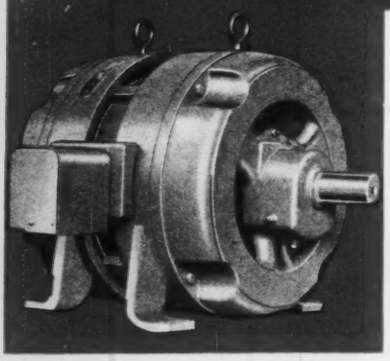


All four elements of IMPERIAL's business creed are essential to your complete satisfaction. We emphasize Quality here to illustrate how conscientiously we live up to the ideals of our slogan.

The Motor pictured above looks like a quality product, doesn't it? The all-steel frame and heavy bonnets are no "false front" either. Bronze sleeve bearings and substantial windings inside are just as rugged as the exterior indicates. IMPERIAL engineers have designed "tough babies" like this (from 1 to 300 HP) for quiet operation, outstanding performance, and long life.

We admit it's hard to get a new customer . . . but it is even harder to take a customer away from the Imperial Electric Company once he does business with us.

What you can't see by looking at the Motor is the quality of the relationship between Imperial and those we do business with. Many of our customers have been with us more than 30 years and they know we live up to our business creed of QUALITY — SERVICE — RIGHT PRICES—COURTEOUS TREATMENT.

Imperial

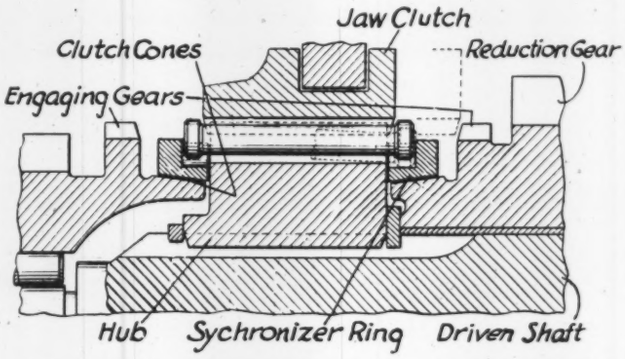
THE Imperial ELECTRIC CO.

Manufacturers of Electric Motors and Generators, 1 HP. to 300 HP. in all modifications

AKRON, OHIO

ated friction clutches. In this patent, assigned to the Borg-Warner Corp., a hub is splined to the driven shaft and located between the engaging gears of the drive shaft and the reduction gear. The reduction gear is continuously driven from the drive shaft by a conventional jack shaft which is not shown in the illustration. A jaw clutch in the form of an annular ring is splined to the hub. Axial motion of this clutch to either the right or left may be affected by a shifting fork which engages the outside of the ring and is operated by means of a shifting lever on the outside of the transmission.

Dumbbell shaped thrust bars, the heads of which have frusto-conical radial surfaces, are set loosely in longitudinal grooves in the hub. The heads rest in V-shaped notches in the synchronizer rings. Conical



Inertia of jaw clutch and thrust bars maintain the bar heads in interfering position until synchronous speed is attained

clutch surfaces are formed on the inside of the synchronizer rings which are designed to mate with the clutch cones.

In operation from the neutral position illustrated (driven shaft is stationary), the nominal amount of friction between the conical clutch surfaces induces the thrust bars to roll up the trailing side of the V-notch in the synchronizer ring. In this position the heads of the bars interfere with the jaw clutch teeth. In attempting to shift the jaw clutch, to the left, for example a thrust is transmitted through the thrust bar head to the synchronizer ring and thus to the cone clutch surface. This frictional engagement accelerates the hub and driven shaft to synchronous speed with the driver. When this speed is reached, acceleration, of course, ceases and the bars are then held against the jaw clutch only by centrifugal force which is easily overcome by the chamfered ends of the clutch teeth acting against the frustro-conical head of the thrust bar. The thrust bars then drop inward radially thus permitting the gears to be engaged.

When it is desired to drive through the reduction gear which, as has been indicated previously, is connected to the main power source by means of a jack shaft, the jaw clutch is shifted over to the right. This thrust is transmitted through the clutch teeth to the right end of the thrust bars and thence to the synchronizer ring. Thus the jaw clutch is again brought up to synchronous speed, this time with the reduction gear, and engagement is again accomplished without danger of damage to the gears.

TORRINGTON NEEDLE BEARING IMPROVES BRAKE AND LANDING GEAR PERFORMANCE FOR KINGHAM TRAILER

1 "Torrington Needle Bearings have increased the efficiency of our brakes and landing gears," says E. J. Lucas, Sales Promotion Manager of Kingham Trailer Company, Incorporated. "They give the quick brake release and application needed in present-day traffic, and they allow easier manual operation of landing gear."

2 Needle Bearings in the brakes fit into approximately the same space needed for plain bushings formerly used in this equipment, yet their low coefficient of friction results in greatly increased mechanical efficiency. Arrows show the small, extremely simple type of housing in which the Needle Bearings are located.

3 Installation of the Needle Bearings in the landing gear and subsequent assembly are simple, inexpensive operations. Kingham engineers report that the slight extra cost of the Needle Bearing, compared to bushings, is negligible in view of the advantages gained.

4 Ogle Hurte, driver for Huey Motor Express, typical user of Kingham Trailers, agrees with Kingham engineers on the advantages of the Needle Bearing in landing gear. "Raising or lowering this new model landing gear is as easy as falling off a log," says Hurte

If you are looking for ways to increase the efficiency of your product, and still keep costs and space requirements low, the Torrington Needle Bearing may be the answer to your problem. Our Engineering Department will be glad to work with you in incorporating the advantages of the Needle Bearing in your product. For more detailed information, write for Catalog No. 109. For Needle Bearings to be used in heavier service, ask our associate, Bantam Bearings Corporation, South Bend, Indiana, for a copy of Booklet 103X.

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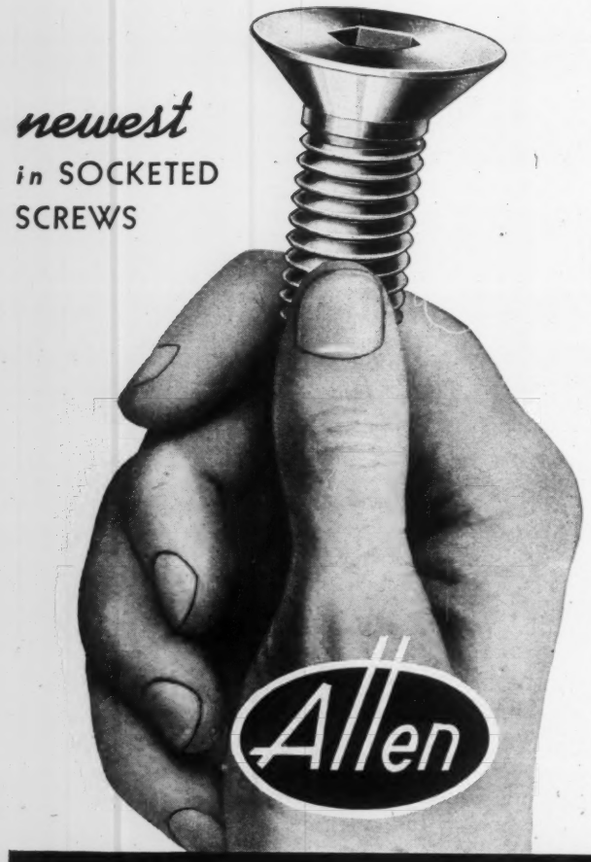
Makers of Needle and Ball Bearings

New York Boston Philadelphia Detroit Cleveland Chicago London, England

TORRINGTON NEEDLE BEARING



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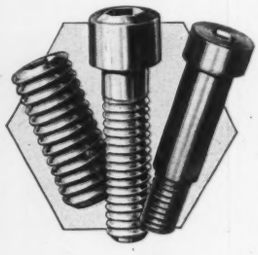
FOR attaining great rigidity of grip, while retaining flush surfaces of machine parts or assemblies. This socketed screw sets up flush when seated in a regular countersunk hole.

"Pressur-formd" of ALLENOY steel by the process that shapes the steel-fibres to the contour of the screw head by continuous grain-flow; *no cut* fibres. This increases strength for tight set-ups.

"Duo-process" threaded, which makes the axial fibres of the steel conform to the contours of the thread profile. *ALL* of the thread surfaces engage in the tapped hole, ensuring evenly distributed friction-pressure over the entire length of the thread. This increases *holding-power* under vibration.

The screw heads are of uniform diameter, each true and perfectly concentric with the body of the screw. When seated the head engages solidly in the countersink. . . Available (from stock) in 90 standard sizes from No. 4 to ¾". *Ask for descriptive folder* C-25. For other types of socketed screws (*at right*), ask for general folder G-21.



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THE ALLEN MANUFACTURING COMPANY
HARTFORD, CONN., U. S. A.

ASSETS to a BOOKCASE

Steel Castings Handbook

Published by the Steel Founders' Society of America, Cleveland; 503 pages, 6 by 9 inches, cloth bound; available through MACHINE DESIGN *for $2 postpaid.*

This volume is probably the most complete work ever compiled on the subject and certainly contains authoritative material, derived direct from members of the society. Naturally it offers much more extensive and concentrated information on advantages, characteristics and applications of steel castings than is available in general handbooks. In addition, a most helpful feature is the list of references following each chapter. Supplementary data in periodical literature is thus put at the reader's disposal.

While all the chapters are valuable, perhaps the best from the designer's angle are those pertaining to physical values; variables affecting the mechanical properties of steel castings; engineering properties of cast steel; properties of alloy steel castings; and steel casting design.

In the latter chapter, considerable stress is laid upon a point which cannot be emphasized too highly, namely, the need for close consultation between designers and foundry engineers. Although all metals have inherent characteristics affecting their treatment, steel is distinguished by the comparatively high volumetric contraction taking place when it transforms from a liquid to a solid. Special attention therefore is necessary to reduce possible stresses acting upon the casting.

Excellently made up and printed on durable coated stock, the handbook combines readability with widespread information. Liberal use of curves has served to enliven the numerous tables. The volume will be a welcome addition to any designer's library.

□ □ □

Welding Metallurgy

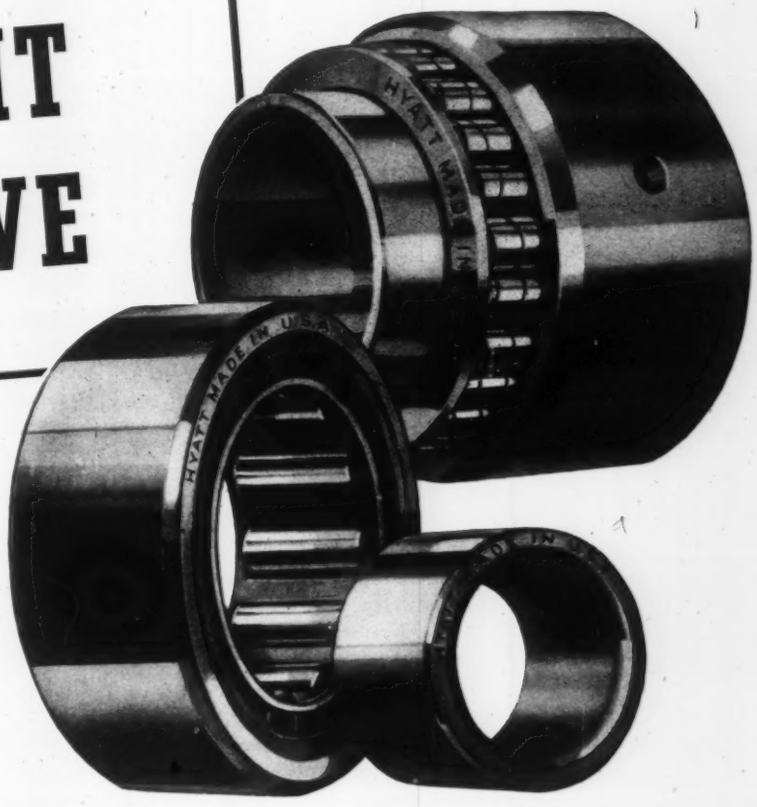
By O. H. Henry and G. E. Claussen; published by the American Welding society, New York; 359 pages, 5 by 7¾ inches, cloth bound; available through MACHINE DESIGN *for $1.50.*

Intelligent application of welding requires a knowledge of the important characteristics of steels from the welding standpoint and of the effect of welding on the steels. First half of this volume, which comprises only lectures, aims to set forth the elementary facts and particularly the basic principles underlying welding metallurgy. The authors have endeavored to simplify the presentation as much as possible without distortion of facts.

Designers probably will find more value in the second half, dealing with concrete problems encountered in welded structures. These problems include the relation of heat and time in welding, brittleness and cracking, shrinkage, preheating and stress relief.

In the effort to compress essential facts into as few pages as possible, certain attractive subjects like nonferrous welding have been touched only lightly.

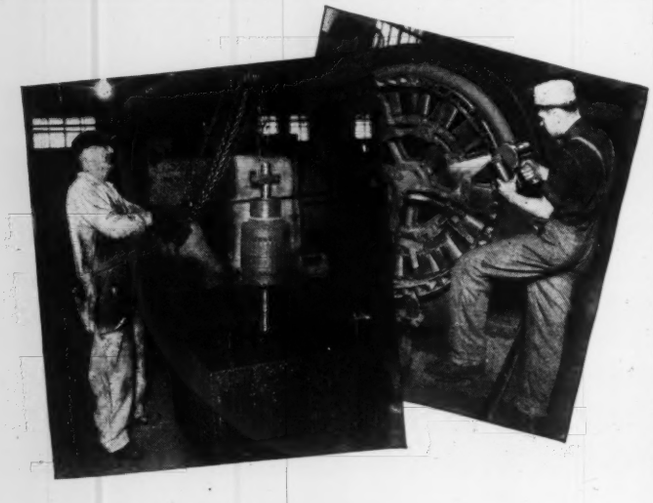
WHERE ONLY THE FIT SURVIVE



HYATT WOUND ROLLER TYPE AND HY-LOAD SOLID ROLLER BEARINGS shown opposite. Inherent design advantages, uniformity and accuracy, along with their capacity for heavy loads, account for the widespread application of these better bearings.

UNDER HEAVY LOADS day in and day out... Hyatts run smoothly and enduringly! No matter what the application—Hyatts keep equipment working... survive where others fail! Everywhere Hyatt Roller Bearings are proving their mettle and are assuring dependable operation and longer equipment life! Let us give you further facts about these better bearings for the machines you build or buy! Hyatt Bearings Division, General Motors Sales Corporation, Harrison, New Jersey; Detroit, Chicago, Pittsburgh and San Francisco.

HYATT *Roller* BEARINGS



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"IRVINGTON" and HARVEL Insulating Varnishes are manufactured in a variety of types and characteristics to fulfill the different requirements and specific purposes of the electrical field. Their development is the result of years of experience in meeting demands for insulating varnishes of the highest quality for dipping, brushing, spraying, vacuum and pressure applications.

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New PARTS AND MATERIALS

Motor Represents Wide Changes

COMPLETELY new, an entire line of polyphase induction motors, in integral horsepower sizes, is announced by General Electric Co., Schenectady. Known as the Tri-Clad motor, it represents one of the most extensive part changes in the history of the company. In all its ratings it features modern appearance, more complete protection, major advances in the insulation of current-carrying parts, and improved bearing design and lubricating arrangements. It also incorporates the cast-aluminum rotor, and pressure-relief system of greasing for ball bearing motors. Instead of the conventional open frame, this motor has a cast iron frame of the box type, with end shields designed to match the frame. Formex magnet wire is used on all ratings. The complete sleeve bearing utilizes hard-tin babbitt centrifugally cast into a steel shell. It is rigidly supported through 360 degrees and is locked in a dustproof and oiltight enclosure by a removable pin.

Modern appearance, more complete protection, better insulation and improved bearing design feature line of motors

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GENERAL purpose alternating current contactors, in sizes 0 and 1 are announced by the Electrical division, Colt's Patent Fire Arms Mfg. Co., Hartford, Conn. They are suitable for handling single or polyphase alternating current motors, or for use as flexible

Important feature of general purpose contactors is three-point ball bearing suspension of the movable electromagnet assembly

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EST. 1867

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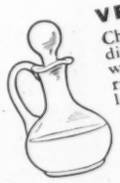

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THE STABILIZED TRACING PAPER

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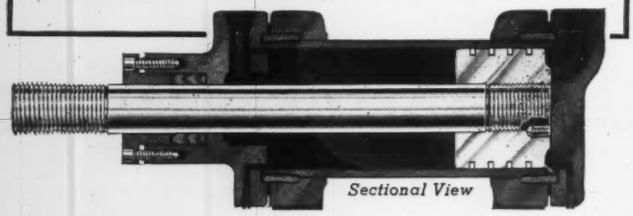
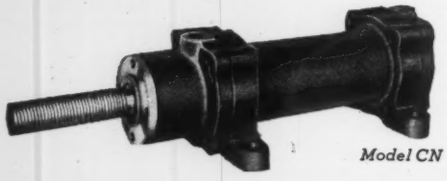
Stronger, Simpler, Easier to Use



Sectional View

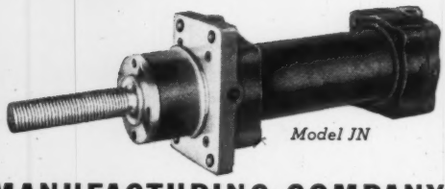
Better use of hydraulic power is available with Hannifin patented no-tie-rod design hydraulic cylinders. This design gives a stronger cylinder assembly, simpler to use, assuring high efficiency operation. Special mirror-finish honing produces a cylinder bore that is straight, round, perfectly smooth—assuring high efficiency piston seal with minimum fluid slip. No-tie-rod design allows end caps to be positioned independently to bring inlet port at top, bottom, or either side. End caps may be removed without collapse of other parts or disturbing the cylinder mounting. Air vent plugs on three sides of each cap allow for a vent at the top when inlet port is at either side or bottom.

Seven standard mountings simplify applications. These cylinders are available in a full range of sizes for any length stroke, with small diameter piston rod, 2 to 1 differential piston rod, or double end piston rod. Write for Bulletin 35-MD with complete specifications.



Model CN

Many other mountings available



Model JN

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•

HANNIFIN
HYDRAULIC CYLINDERS

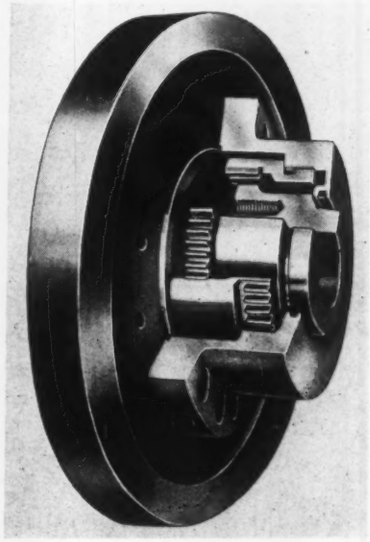
relaying devices for control systems such as used in machine tools, switchboards and special control panels. An important feature is the three point ball bearing suspension of the movable electromagnet assembly, reducing friction to a minimum and guiding contacts into correct alignment. Contactors are of the vertical solenoid type with the weight of the laminated core itself sufficient to open the contacts. They can be supplied open as type *U* or in the standard type *A* sheet steel enclosure with knockouts in four sides and back.

Plastic Compound Contains Graphite

THIRD in the 1900 series of high impact phenolic molding compounds, Durez 1910 is announced by Durez Plastics & Chemicals Inc., North Tonawanda, N. Y. It contains graphite and was developed for parts where minimum frictional resistance is desirable. It has a particle size comparable to dry rice and may be preformed easily. Specific gravity is 1.45.

Flexible Coupling Saves Space

TO SAVE space and also secure full flexibility, the Manger flexible coupling has been developed by Farrel-Birmingham Co. Inc., Buffalo, N. Y. For connecting a shaft directly to a flywheel, brake drum or flange, this coupling provides complete flexibility with approximately one-half the axial clearance usually required. It is equally applicable for connecting two free-ended shafts in combination with a solid, flanged, half coupling. Compensation for misalignment is made by an internal sleeve which floats between an externally geared hub and an internally geared covering sleeve. The internal sleeve, engaging the hub and outer sleeve, is free to slide and rock, adjusting perfectly for differences in alignment.



Coupling provides complete flexibility with approximately half usual axial clearance

Announce Electronic Relay

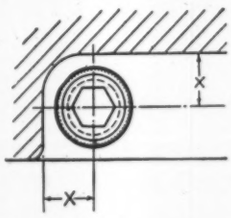
ATTRACTIVELY housed in a cast alloy chassis with a compact molded cover, a photoelectric relay is announced by General Electric Co., Schenectady. It will operate at speeds up to 150 interruptions per minute and a minimum of 40 foot-candles at the phototube with not more than 15 foot-candles of extraneous light present. The relay has a controlled contact rating of 10 amperes at 115 volts alternating current, with two normally open and two normally closed con-

For Speedier Assembly..

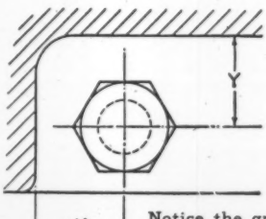
For More Compact Designs..

For Extra Neatness..

DESIGNERS CHOOSE "UNBRAKO" Knurled Socket Head Cap Screws



See how the Knurled "Unbrako" snuggles right into the corner.



Notice the great open spaces necessary for the hex head and wrench.

Distinctive cold-forged knurled "Unbrako" Better-Grip Heads—the standard for years—not only enhance the finished appearance of equipment on which they are used but provide a non-slip gripping surface which speeds up production. And by two simple but effective methods "Unbrako" Socket Screws can be locked into place after counter-sinking in either hardened steel, cast iron or soft metals.

The comparative diagrams shown at left illustrate how simple it is to achieve much narrower and therefore thinner flanges without sacrificing strength. Resulting compactness insures decided savings in material, weight, cost . . . increases holding power by bringing screw head closer to the joint.

No other socket screw has all these unique advantages . . . specify them for your equipment!

STANDARD PRESSED STEEL CO.

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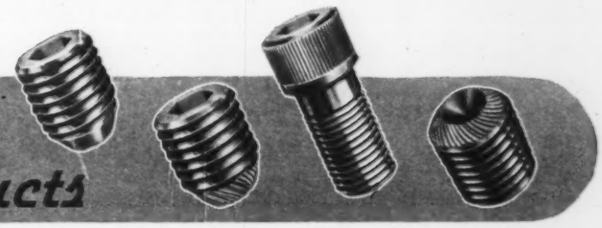
UNBRAKO Screw Products



"to the company that builds its own clutches"

Are you slowing up production on your major unit by tying up machines on an accessory that you could buy better and cheaper from a specialist?

● Manufacturers who ordinarily find it practicable to make many of their own parts and accessories . . . find that, in these "rush order" times, their equipment can be used more profitably when devoted to production of major units only . . . leaving the specialized parts to the *parts specialist.*

When it comes to clutches, for all types of power-driven machinery, these companies naturally take advantage of the Twin Disc Clutch Company's twenty-three years of specialization. Why not ask our engineering department for suggestions?

- *Left: Torque Converter*
- *Right: Heavy-Duty Clutch*
- *Bottom Left: Power Take-Off*
- *Bottom Right: M. T. Clutch*

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES
REG. U.S. PAT. OFF.

TWIN DISC CLUTCH CO. • 1325 RACINE ST. • RACINE, WIS.

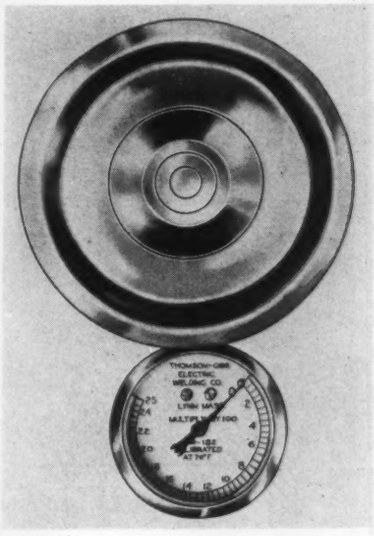
tacts. Coil of the relay is energized when the light at the phototube is reduced below 30 foot-candles. Carefully styled without sacrificing utility, this relay

Coil of photoelectric relay is energized when light is reduced below thirty foot-candles at phototube

has a light gray finished chassis which contrasts effectively with the black molded cover.

Announces Welding Pressure Meter

IMPROVEMENTS in the Thomson resistance welding pressure meter made by Thomson-Gibb Electric Welding Co., Lynn, Mass., insure more accurate readings and lasting accuracy of the instrument. The meter consists of an oil-filled diaphragm connected to a gage made with a bronze-bushed movement. A plunger tube plug stabilizer in the stem protects the gage against damage from sudden applications of pressure and eliminates the danger of the needle's being



Plunger tube plug stabilizer in stem of welding pressure meter protects gage from damage

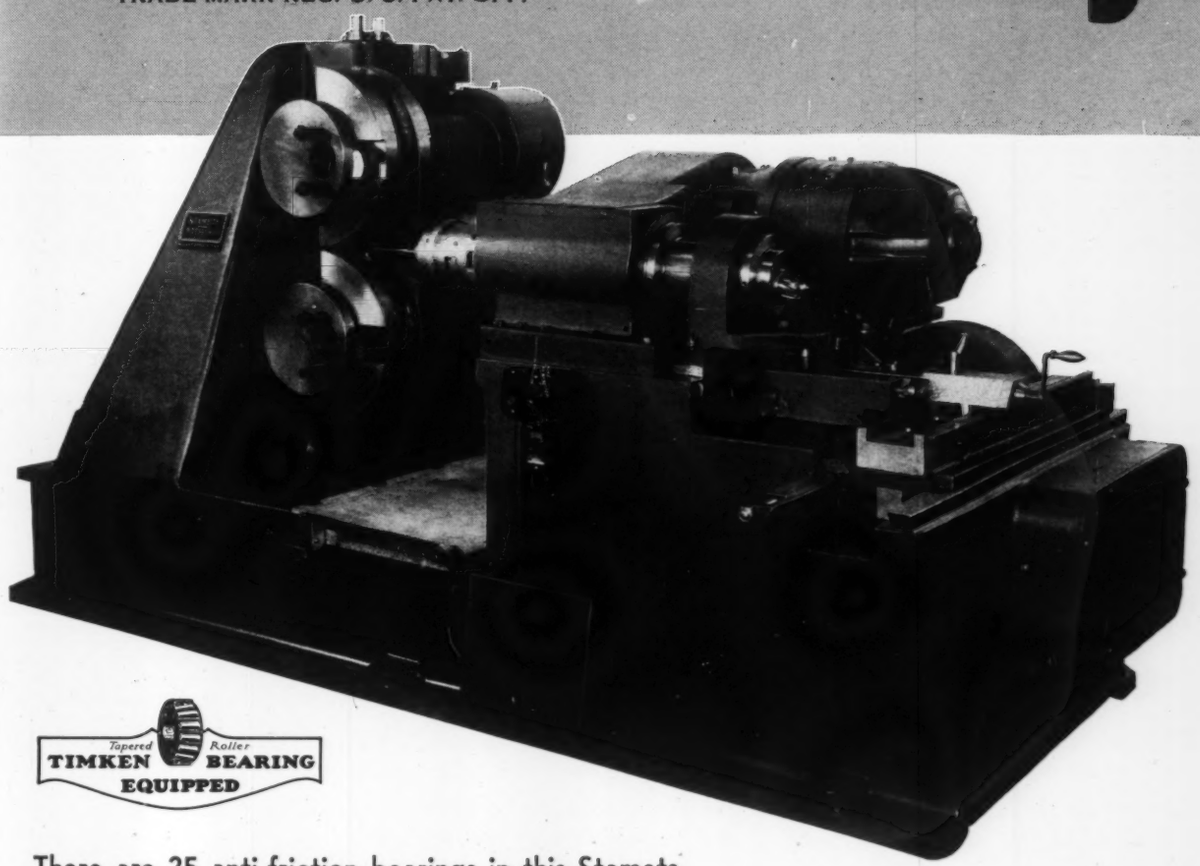
forced off the scale or turned on its shaft. The diaphragm unit is resistance welded throughout and is designed so that the overall thickness is approximately one inch, making the meter suitable for use on practically all machines. Meters are available to cover eight ranges of pressure.

Circuit Breaker Has New Quencher

WITH three direct-acting overload and inverse time delay features, the type LX circuit breaker has been improved by the I-T-E Circuit Breaker Co., Nineteenth and Hamilton streets, Philadelphia. A three-pole device, it is available in ratings from 100 to 1600 amperes, 250 volts direct current, 600 volts alternating

21 out of 25 are TIMKEN bearings

TRADE-MARK REG. U. S. PAT. OFF.



Tapered Roller TIMKEN BEARING EQUIPPED

There are 25 anti-friction bearings in this Stamets Die-Finishing Machine; 21 of them are TIMKEN Tapered Roller Bearings.

This machine is used for precision boring and grinding dies from 11" to 17" in diameter. The need for bearings that will help to establish and maintain the close tolerances demanded is reflected in the machine manufacturer's selection.

TIMKEN Bearings long have received the preference of the machine tool industry as a whole for work spindles and other important positions in heavy duty machines of all kinds. Make sure you have them in your new equipment.

TIMKEN
TAPERED ROLLER BEARINGS

Manufacturers of TIMKEN Tapered Roller Bearings for automobiles, motor trucks, railroad cars and locomotives and all kinds of industrial machinery; TIMKEN Alloy Steels and Carbon and Alloy Seamless Tubing; and TIMKEN Rock Bits.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

32 of these 5,000 lb. castings made of ABSCO Meehanite have been delivered and more are on order.

A SURE TEST of CASTING SKILL

Successful production of these intricate machine castings from ABSCO Meehanite is a tribute both to the ability of our engineers and foundrymen and to the balanced characteristics of Meehanite itself.

ABSCO Meehanite castings are supplied in quantity lots for production parts or singly to individual design.

Through SELECTIVE PROCESSING a grade of ABSCO Meehanite is available to fit your needs for any of these qualities

1. ***Combined strength and toughness***
2. ***Acid and corrosion resistance***
3. ***Abrasion and erosion resistance***
4. ***Pressure tightness***
5. ***Ability to stand shock and strain***
6. ***Intense hardness through chilling or heat treatment***

Write for full particulars to Department D

THE AMERICAN BRAKE SHOE AND FOUNDRY COMPANY

BRAKE SHOE AND CASTINGS DIVISION

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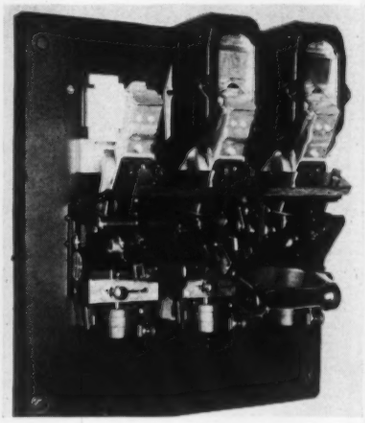
332 South Michigan Ave., Chicago, Ill.

current. New arc quenchers developed for this device have magnetic vanes molded into the insulating barriers on each side of the main contacts. They are magnetized upon opening of the arcing contacts and the field set up by the current forces the arc into the extinguisher chamber. In this chamber thick copper

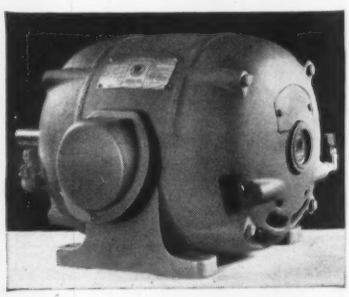


Construction of arcing contacts is indicated in circuit breaker which has one of arc quenchers removed

plates are arranged to cool the arc, create a turbulent gas condition and provide a cooling draft across the arc core. Illustration shows one of the arc quenchers removed and indicates construction of the arcing contacts.

Induction Motors Improved

OPEN type sleeve-bearing induction motors for general purpose drives are announced by the Westinghouse Electric & Mfg. Co., East Pittsburgh. These squirrel cage motors are designated type CS and are available in ratings from ½ to 5-horsepower, at speeds from 875 to 3600 revolutions per minute, for operation on 110, 220, 440 and 550 volts, 2 and 3-phase alternating current. Rigid cast frames maintain constant



General purpose squirrel cage motors are available in ratings from one-half to five horsepower

air-gap between the stator and the rotor. Frame improvements include new sealed sleeve bearings having a combination vestibule and felt washer seal, and a larger oil capacity. Elimination of sharp corners and projections has greatly improved appearance and castings are buffed to produce a smooth, even surface.

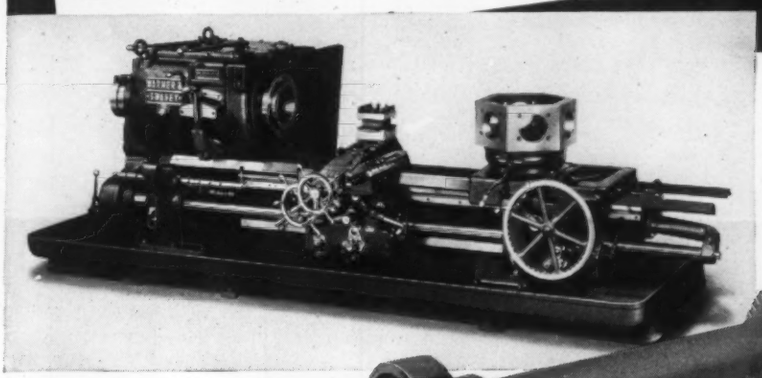
Alloy Gear Steel in Stock

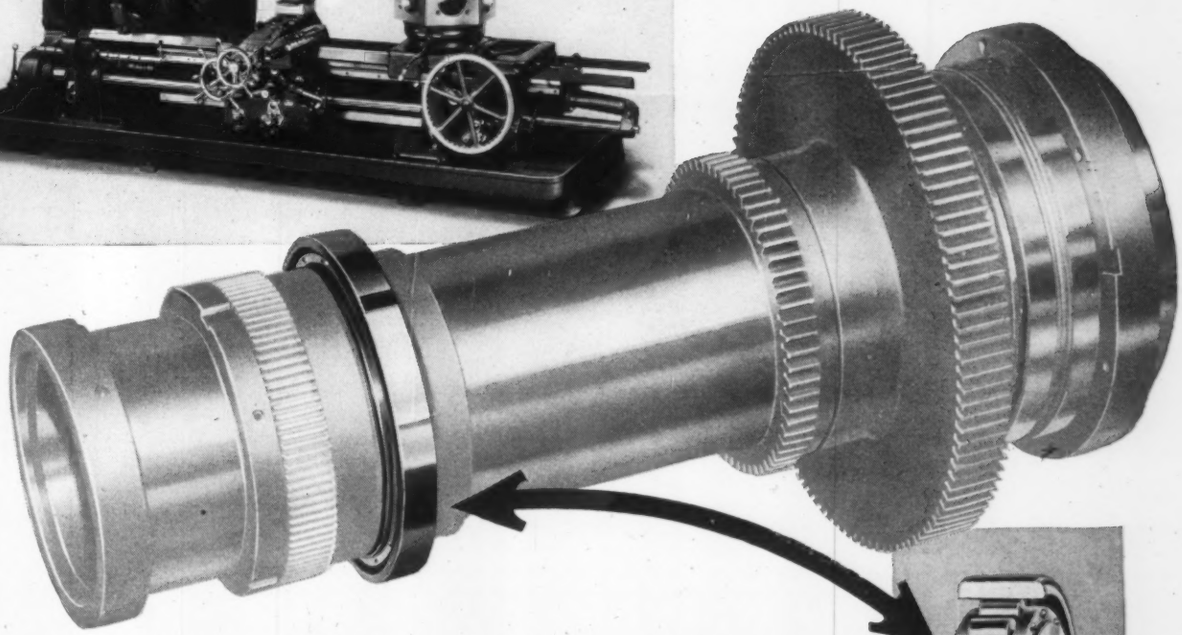
FOR immediate shipment, S.A.E. 4640 gear steel is now carried in stock by Joseph T. Ryerson & Son Inc., Chicago. Stocks include hot rolled annealed rounds, in sizes from 1 to 5 inches. Because of its high fatigue resistance, toughness and ability to attain a high degree of hardness with minimum distortion in heat treatment, S.A.E. 4640 is one of the best gear steels of the medium carbon grades. Only a mild quench is needed after heat treatment. This steel also

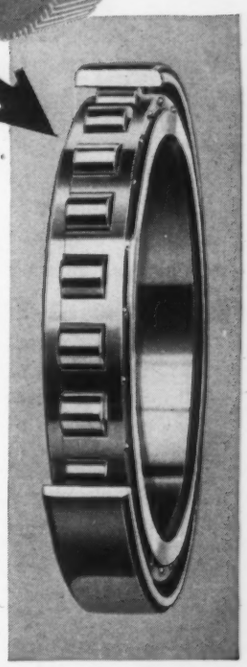
No Machine Can Be More Accurate Than Its Bearings

So Warner and Swasey use

"NORMA-HOFFMANN" PRECISION ROLLER BEARINGS







Describing its latest machines, Warner and Swasey Co., Cleveland, O., states, "they reduce (often eliminate) waste, . . . help you improve your product, . . . last for years with negligible maintenance." Translated into terms of lathe construction these results indicate, among other vital features, a lathe spindle that is rigid, chatter-free, rugged, and lasting in its accuracy.

In achieving these qualities in their 8" and 9" Model 4-A Turret Lathes, Warner and Swasey engineers employ NORMA-HOFFMANN EXTRA LIGHT PRECISION ROLLER BEARINGS at the back end of their main spindle.

The rigid mounting of both inner and outer rings combines with the extreme PRECISION of the bearing, to eliminate radial looseness, vibration and chatter. * * * * Unimpeded endwise movement of the cylindrical rollers across the straight outer ring provides a simple solution for expansion and contraction of the spindle, with but a single bearing. * * * * These PRECISION Roller Bearings permit a simpler, more compact design with greater capacity and cooler operation at high speeds. Their initial PRECISION and close internal clearance are maintained indefinitely without adjustment.

There's a NORMA-HOFFMANN PRECISION BEARING for every load speed and duty. Write for the Catalog. Let our engineers work with you

NORMA-HOFFMANN BEARINGS CORP'N — STAMFORD, CONN., U. S. A.

DIRECTORY
OF
MATERIALS

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EXTRA COPIES ARE AVAILABLE

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All listings have been brought up-to-date and a new section covering Producers of Machine Finishes has been included in this new edition, which supplemented the October 1940 issue of MACHINE DESIGN.
The Directory is divided into the following sections:

1—Alloys, Ferrous and Nonferrous, by Tradenames.
2—Plastics and Nonmetallic Materials, by Tradenames.
3—Producers of Tradenamed Materials.
4—Stampings Producers.
5—Forgings Producers.
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7—Plastics Molders.
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Each listing of material has a helpful key to principal characteristics, permitting quick and easy reference to those materials for which an engineer may be searching. Below is a scale of prices for quantities. Single copies are twenty-five cents, postpaid.

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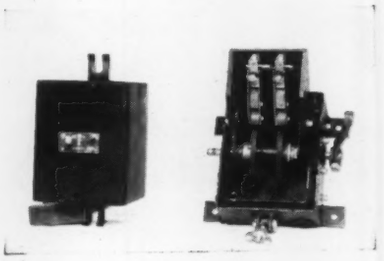
●

shows higher impact resistance at high hardness than other .40 per cent carbon steels in approximately the same range. It can be satisfactorily machined at 400 brinell.

Limit Switch Is Cam-Operated

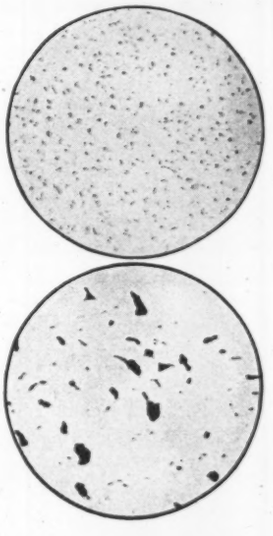
A CAM-OPERATED limit switch with contacts arranged to swing open for easy inspection is announced by the Westinghouse Electric & Mfg. Co., East Pittsburgh. Known as the XC-23 limit switch, it is available with ratings of 2 amperes at 600 volts direct current and 25 amperes at 110 volts alternating current. Contacts may be either normally closed or open. By means of a camshaft, rollers make or break the contacts at any point on the travel. The switch may be actuated either by a revolving shaft coupled to its camshaft or by the movement of an operating lever attached to the shaft. The moving contacts are self-aligning, with a compensating type operating finger.



By means of camshaft, rollers make or break the contacts at any point of travel in limit switch

Lead Dispersed in New Bronze

PRODUCED for a wide range of applications, a new bearing bronze has been developed by Monarch Alloys Co., Ravenna, O. Known as Monarch metal, the bronze is alloyed in various high-lead combinations. Its elements are combined in a hermetically sealed crucible which protects them from contact with furnace gases or oxygen while melting and the resulting alloy is watercooled by a special process. Because abrasive tin and lead oxides are prevented in the melting and casting process, bearings made of this metal



Top photomicrograph shows fine lead dispersion in new bronze, while large lead particles are visible in other specimen

STEEL CASTINGS STAND UP . . .

under Extremes of Temperature and Pressure

A leading manufacturer of steam turbines tells us: "Modern requirements of higher pressure, higher temperature and shock-withstanding qualities have brought us to the very considerable use of steel castings."

That is not an unusual comment. Many industries have met increasingly severe conditions with steel castings. Invariably they provide greater strength and safety than materials formerly used.

Steel castings bring you other advantages as well. They save on machining, fitting and assembly time, permit scientific, streamlined weight distribution, often save on over-all weight, and afford a wide selection of mechanical properties.

Whatever you build out of metal, where strength and stability are vital, consider using more steel castings. Your product will be a better one, and often you'll broaden your market through lower costs.

For details and recommendations, consult your local foundryman. He knows your problems, and will gladly work with you. Or, you may freely consult Steel Founders' Society, 920 Midland Building, Cleveland, Ohio, where broad experience is ready to serve you.

MODERNIZE YOUR PRODUCT WITH

STEEL CASTINGS

PUT **OHIO GEARS**
in the new
MORRISON AUTOMATIC, SIDE SEAM STITCHER

● Because Ohio Gears meet exactly, their engineering specifications:

Because Ohio Gear dependability and long life have been thoroughly proved:

Because of the excellent service rendered by the company:

The Harris-Seybold-Potter Company uses Ohio Mitre Gears in the stitching head of their new Morrison Automatic Side Seam Stitcher.

The result? High speed operation, uniform stitch spacing at correct angularity and lower costs for machine users.

You, too, may find these same facts an excellent reason to select Ohio Gears or Speed Reducers for the machines you build. Check into it now. Write, wire or phone the nearest representative.

THE OHIO GEAR CO.
1338 E. 179th Street • Cleveland, Ohio

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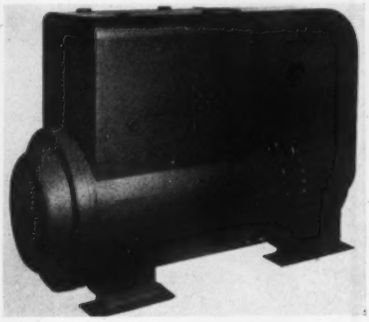
2319 N. Ninth Street

OHIO GEARS

are said to run with reduced friction, heat and noise. Compression and heat resistance and hardness are other advantages claimed for the new alloy.

Larger Drive Units Announced

THREE additional units of its all-electric, adjustable speed drive are announced by Reliance Electric & Engineering Co., Cleveland. New units are 20, 25 and 30-horsepower. The same principle of speed control is used as in the other sizes which range from 1-horsepower up. For the sake of compactness the unit has been mounted horizontally instead of vertically as in the smaller sizes. Secondary circuits run from the control unit to the three other elements of the drive, namely, the motor, speed adjuster and pushbutton station. The motor is designed especially for adjustable-speed service and can be supplied in a variety of types.



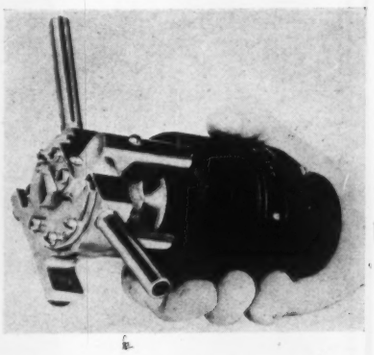
For compactness, larger unit of adjustable speed drive is mounted horizontally

Strips Facilitate Use of Controls

TO FACILITATE the use in multiple of toggle switches, pushbuttons, and other electrical controls, a line of standardized mounting strips is announced by the H. R. Kirkland Co., Morristown, N. J. These strips are stainless steel with a ripple finish and have beveled ends. Each strip is mounted with two screws directly to machines.

Midget Pump Is Self-Priming

ADDITION of model UT midget positive pressure pump to its line is announced by the Eastern Engineering Co., 45 Fox street, New Haven, Conn. Self-priming, this pump is suitable for applications in which its location makes this feature desirable. Its light weight and small size make it particularly adaptable to all installations requiring pumping of thin liquids. Its



Motor armature and impeller of midget pump are mounted on single shaft, making coupling unnecessary

Designed, built and tested as a Gearmotor
WESTINGHOUSE DOUBLE-REDUCTION GEARMOTOR
Building both gears and electric drive in its own plants enables Westinghouse to furnish gearmotors that will handle full motor torque.
POSITIVE SPLASH LUBRICATION—assures trouble-free operation of drive.
SPLIT CASING—gives easy access to rotating parts.
SLOW SPEED SHAFT—delivers exact hp and speed required.
COMPACT MOUNTING—readily installed in small space.
BALL BEARINGS—cut friction losses to minimum.

In the design and construction of Westinghouse Gearmotors, Westinghouse engineers do not consider the reduction gears and the electric drive as separate units. A Westinghouse Gearmotor is designed, built and tested as a complete slow speed drive —a drive in which all parts are matched to provide maximum performance. By building its own gears Westinghouse gives the geared drive exactly the characteristics necessary to get the highest efficiency possible from the complete unit.

GEARMOTORS GIVE THE ADVANTAGE OF HIGH SPEED MOTOR EFFICIENCY & POWER FACTOR

Another advantage for the user is the fact that Westinghouse Gears are made of heat-treated, forged steel, cut by the hobbing process—the most accurate method of gear cutting yet devised. This assures quiet operation and the ability of the reduction gears to transmit the full torque of the motor under load and to withstand the shocks of severe service.

For complete information on how you can cut operating costs for your slow speed drive requirements, write or call Westinghouse Electric & Manufacturing Company, Dept. 7-N, East Pittsburgh, Pa.

J-07180

Westinghouse

GEARED DRIVES

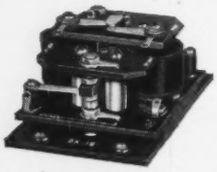
★ The speaker of the evening wears full-dress . . . while the "public address" technician does his work in overalls. But, with both, its the DOING of a JOB that counts.

RELAYS, too, wear a coat of polished chrome and gleaming bakelite . . . or the dull raiment of strict utility. In either case . . . you depend on RELAYS by GUARDIAN for that unfaltering performance that only a QUALITY product can deliver.

Whether your electrical control problem calls for deluxe CUSTOM-TAILORING . . . or "mass-production-at-a-price," you get the best control for the job using

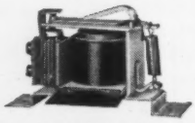
RELAYS by GUARDIAN

GUARDIAN offers matched-to-your-product electrical control. From more than 7000 standard control parts, GUARDIAN engineers can give you a "special" relay . . . perfectly matched to your job . . . to your size . . . to your price and production schedule.



Series BK—16 Relay. Built to minimum tolerances and the most exacting requirements in production quantities for the U. S. Signal Corps.

Get Guardian's 1941 Catalog now . . . or send your control problems for FREE ENGINEERING ADVICE. Find out how Guardian's accuracy, speed and economy keeps purchasing happy . . . production pacified . . . engineering contented . . . field service at a minimum.



Series 120 AC Relay. This relay which sells for less than $1 has operated over 85,000,000 times in an electric fence control, and still remains in excellent condition.

And These Are Not the Extremes in the Guardian Relay Line!

Write for New Guardian Catalog "D" Today. No Cost or Obligation!

GUARDIAN ELECTRIC

1621 W. Walnut St. Chicago, Illinois

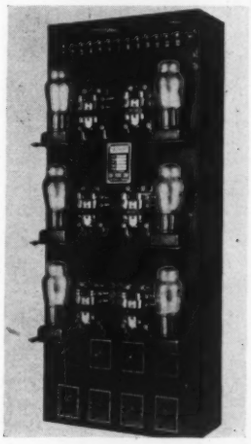
maximum pressure is 35 pounds per square inch and maximum volume is three gallons per minute. It has a universal fan-cooled motor, 1/20-horsepower, alternating or direct current. Motor armature and pump impeller are mounted on a single shaft, making coupling unnecessary and assuring perfect alignment.

Starter Resists Corrosion

FOR use in corrosive or hazardous gas locations, an oil-immersed combination alternating current starter has been developed by General Electric Co., Schenectady. It is available in two forms, with or without circuit breaker. A one-piece cast-iron head, used in both forms, permits conduit entrance from five directions. As protection against external corrosion, stainless steel and monel metal are used for all exposed parts, and a copper-bearing steel tank and the cast-iron head provide additional protection. Reversible tips prolong contact life and an isothermic induction temperature relay immersed in the oil gives protection against harmful overloads.

Controls Complicated Sequences

A COMPLICATED sequence of accurately timed spot welded operations is made possible by a specially designed electronic welding timer made by the Weltronic Corp., 2832 East Grand boulevard, Detroit. For welding of heavy ferrous sections, the timer controls various operating sequences including low weld current, high weld current, initial low welding pressure, impact forging high pressure, cool time, hold time, etc. Eight rapid selective type control knobs permit the welding supervisor to "dial" for the proper intervals of pressure and welding current, for interruptions of both, and for the proper cool time following welding.

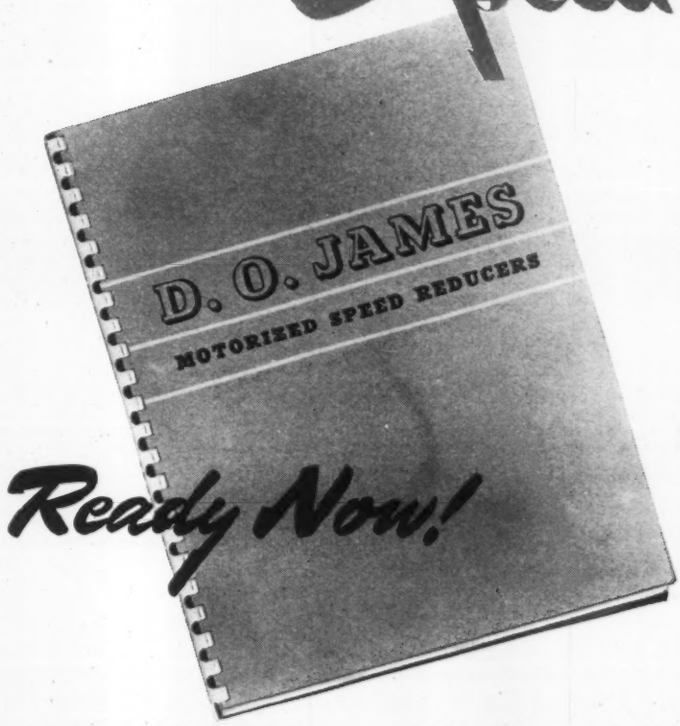


For spot welding heavy iron and steel sections, electronic timer controls various operating sequences

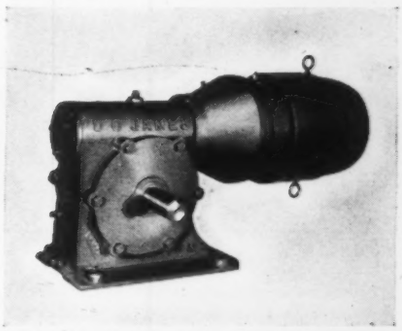
Enamels Air-Dry Quickly

A LINE of synthetic enamels that air-dry so hard in 24 hours that they will not "paper print," is announced by Maas & Waldstein, Co., Newark, N. J. The new finishes have a chlorinated-rubber base and are known as Coprene enamels. They air-dry dust-free in a few minutes. The hardening extends through the coating and is not merely a surface change, making the finish resistant to handling or wrapping. These enamels are supplied in clear, black, white and colors, and also in silver, copper, and other metallic lusters. Other advantages claimed include good adhesion, good resistance

MOTORIZED Speed Reducers



D. O. James Motorized Reducers are precision manufactured to meet the requirements of service for which they are designed. They have the highest possible efficiency, accessability and are most compact.



Motorized Worm Gear Reducer

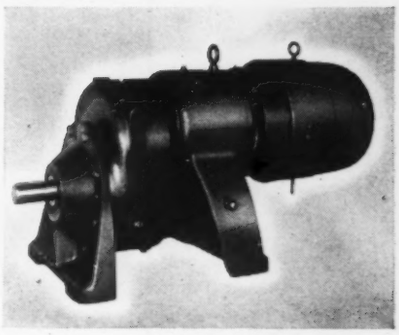
THIS CATALOG CONTAINS

112 pages of engineering data, weights and prices of the D.O. James line of Motorized Reducers. It lists completely, selection tables, service factors and character of load. Information therein will prove helpful to your engineering department in the selection of the proper type of Motorized Reducer.

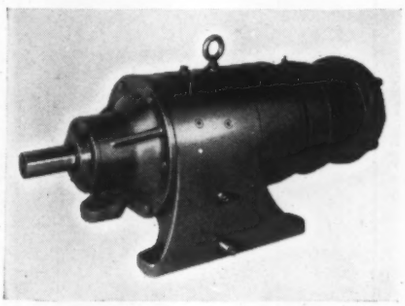
Motorized Worm Gear Reducer
With either horizontal or vertical drives. Made in 11 sizes, ratios 6 to 65:1 and a horse power range of 1/8 to 50 H. P.

Motorized Helical Reducer
With either horizontal or vertical drive. 13 sizes, ratios 1.2 to 9:1. 3/4 to 50 H. P.

Motorized Planetary Reducer
Horizontal and vertical drive, made in 35 sizes, ratios 10 to 1200:1, 3/4 to 75 H. P.



Motorized Helical Reducer



Motorized Planetary Reducer

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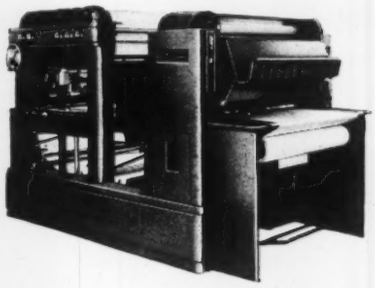
to weather and household chemicals, and ability to retain gloss and flexibility.

Engineering Dept. Equipment

Printer Combines Two Models

LATEST addition to the line of continuous blueprinting machines made by the C. F. Pease Co., 2601 West Irving Park road, Chicago, is the Model 22-16. It consists of a Model 22 printer operating in conjunction with a Model 16 washing and drying machine. Sliding contact in the printer smooths out roughness present in all tracings and three-speed lamp control permits lamps to be operated on 10, 15 or 20 amperes as desired. Frequent dryer heat changes are

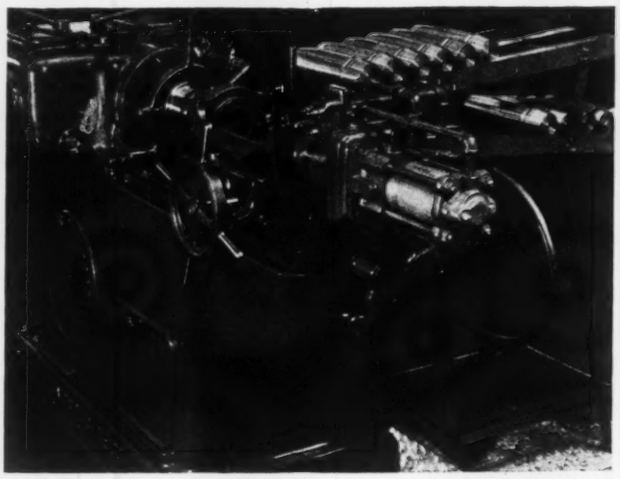


Sliding contact in blueprinting machine smooths out roughness present in all tracings

avoided because the mechanical operating speed remains the same. The washer and dryer has a horizontal water wash, a quick change chemical applicator which gives a change-over from blueprints to negatives in 30 seconds, and five aluminum drying drums.

Correction

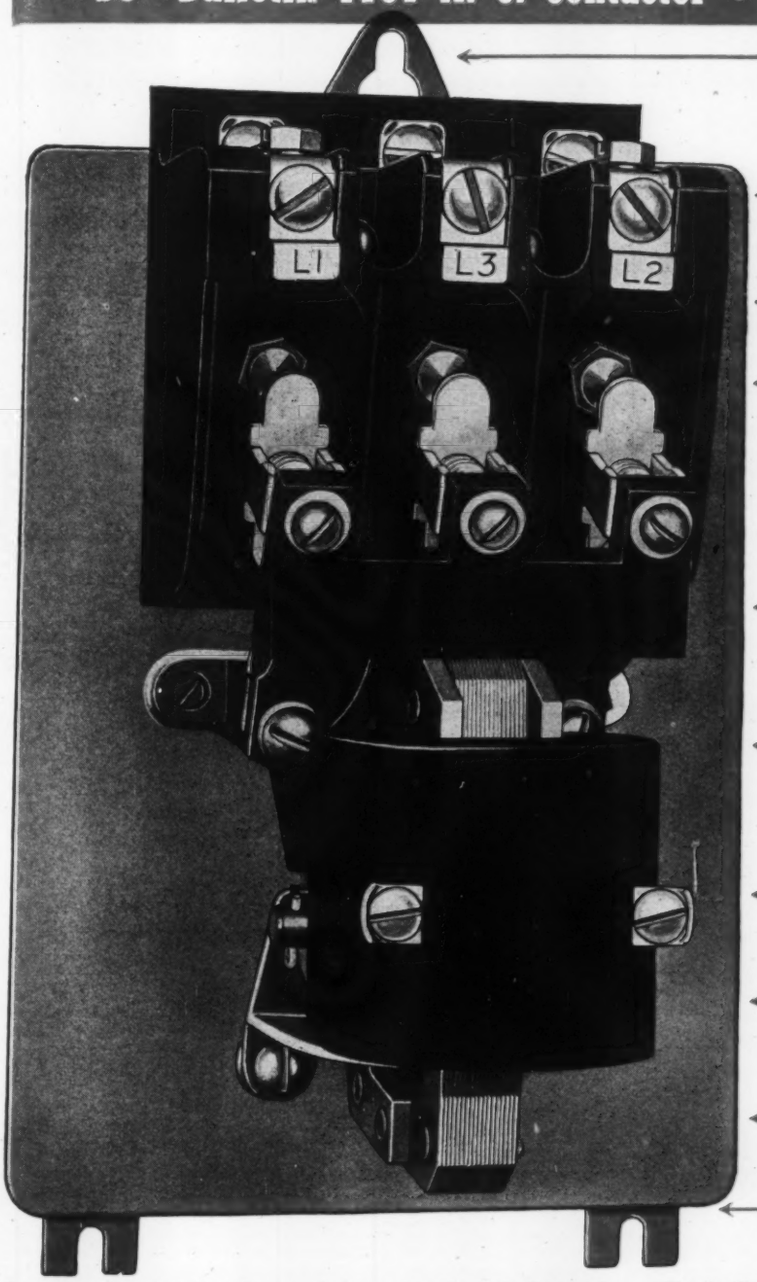
DUE to a last-minute change, the caption headed "This Month's Cover" in the "Design Features" center spread of the December issue of MACHINE DESIGN did not cover details of the machine shown on the cover. A Landis machine designed especially for



tapping the nose end of artillery shells ranging in size from 75 to 155 millimeters was shown on the cover. The caption, however, applied to a household mixer which appears in the spread for January, with

The Latest Addition—

"3C" Bulletin 7707 A. C. Contactor • 15 or 25 Ampere Ratings



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← FRONT CONNECTIONS, TIGHTENED OR LOOSENED WITH SCREWDRIVER.

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← STANDARD STEEL, DEAD BACK MOUNTING PLATE, PARTICULARLY ADAPTED TO MOUNTING ON STEEL PANELS.

← TAPPED COIL TERMINALS.

← LIBERAL CAPACITY, FORM WOUND OPERATING COILS.

← VERTICAL LIFT, HINGED ARM HAMMER HEAD MAGNET DESIGNED FOR HIGH SPEED OPERATION.

← SIMPLIFIED MOUNTING.

On Switches of 3 poles or less, a total of 2 Control Circuit Contacts either Normally Open, or Normally Closed can be provided, mounted on the Standard Steel Mounting Plate. Each Control Circuit Contact consists of a Double Break, Silver-to-Silver contact mechanism operated by a rod mounted on the main arm.

Each Control Circuit Contact mechanism is mounted on its own molded Bakelite Base, attached by 2 screws to the Steel Mounting Plate.

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the correct caption. The error is much regretted.

Mechanical features of Landmaco threading machines are found in the shell tapper, which also has a special carriage comprising a work-supporting cradle, a hardened and ground bushing supporting the nose end of the work and a female center supporting the base end. Movement of the center is actuated by an air cylinder at the rear of the carriage and is controlled by a convenient lever. Machine spindle has a collapsible tap with internal ducts through which coolant is conveyed directly to the cutting edges of the chasers.

Meetings and Expositions

Jan. 6-10—

Society of Automotive Engineers. Annual meeting and exhibit to be held at Book-Cadillac hotel, Detroit. John A. C. Warner, 29 West Thirty-ninth street, New York, is secretary and general manager.

Jan. 8—

American Washer and Ironer Manufacturers association. Annual meeting to be held at Morrison hotel, Chicago. J. R. Bohnen, 80 East Jackson boulevard, Chicago, is secretary.

Jan. 9-11—

Institute of Radio Engineers. Annual meeting and exhibit to be held at Pennsylvania hotel, New York. Harold P. Westman, 330 West Forty-second street, New York, is secretary.

Jan. 11-13—

American Engineering council. Annual meeting to be held at Mayflower hotel, Washington. Col. L. B. Lent, 919 Seventeenth street, Washington, is secretary.

Jan. 12-16—

National Association of Dyers and Cleaners. Annual meeting and exhibit to be held at Municipal auditorium, Kansas City. J. M. Matson, Silver Spring, Md., is managing executive.

Jan. 13-16—

Coin Machine Industries Inc. Coin machine exposition to be held in Chicago. Additional information may be obtained from Theodore R. Sills, 43 East Ohio street, Chicago.

Jan. 19-24—

Canning Machinery & Supplies association. Annual meeting and exhibit to be held at Stevens Hotel, Chicago. S. G. Gorsline, Lock Box 430, Battle Creek, Mich., is secretary.

Jan. 21—

Automotive Tool and Die Manufacturers association. Annual meeting to be held at Hotel Statler, Detroit. Chester A. Gahn, 15 Boulevard building, Detroit, is secretary.

Jan. 23-24—

Northwest Petroleum association. Annual meeting and exposition to be held at Radisson hotel, Minneapolis. Elwin E. Hadlick, 616 Builders Exchange, Minneapolis, is secretary.

Jan. 27-29—

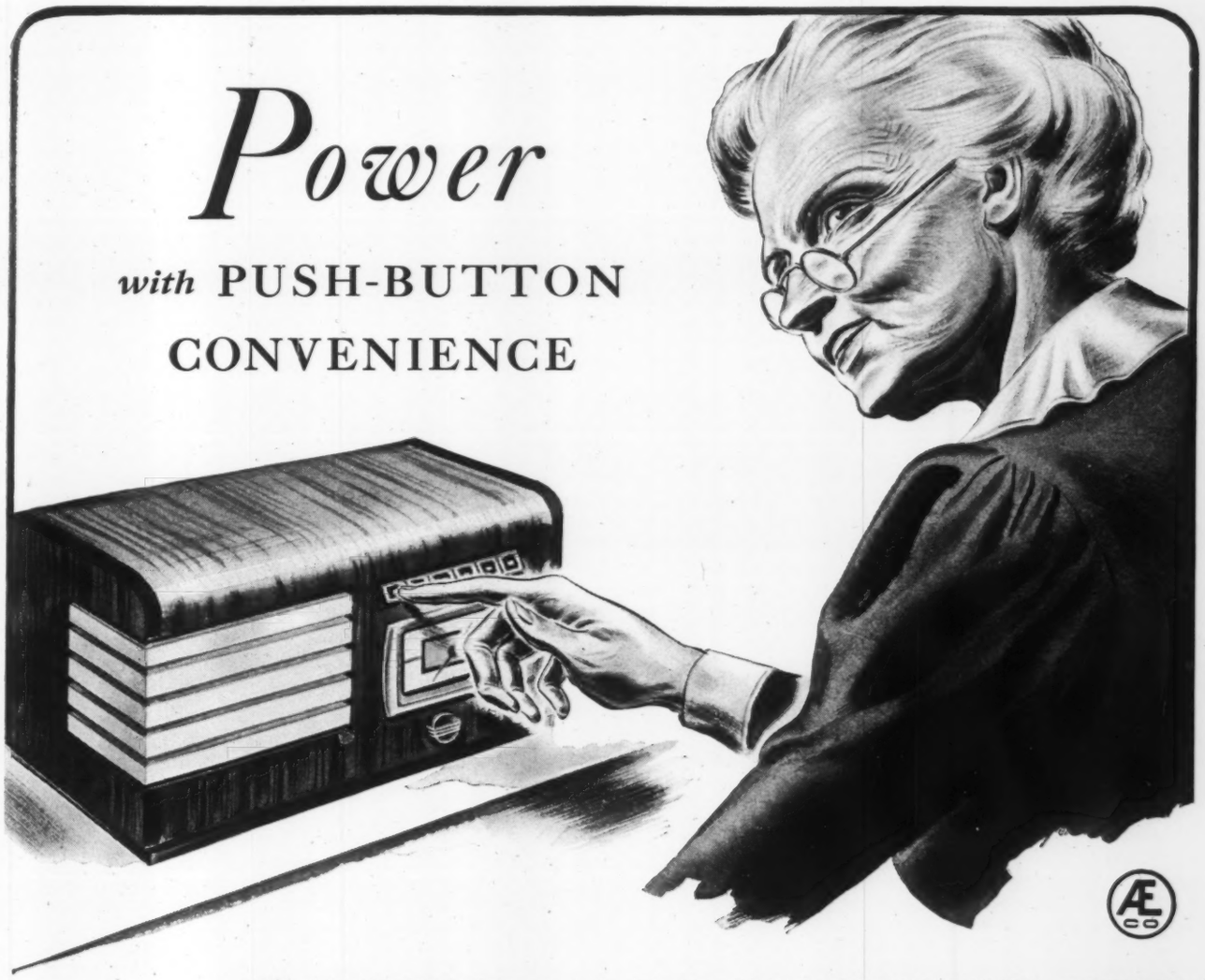
National Association of Air Filter Manufacturers. Annual meeting to be held at Muehlebach hotel, Kansas City. J. R. McConnell, 215 Central avenue, Louisville, Ky., is secretary.

Jan. 27-31—

American Road Builders association. Annual meeting and exhibit to be held at Pennsylvania hotel, New York. Charles M. Upham, Seventh Floor, International building, Washington, is engineer-director.

Power

with PUSH-BUTTON CONVENIENCE



AN ADVANTAGE OF A-E-CO HELE-SHAW FLUID POWER

IF you don't already own a push-button radio you probably have a longing for one. We don't blame you. But, remember, your own customers like push-button convenience, too, on machines you design or build. You can give it to them with Hele-Shaw Fluid Power (oil under pressure for driving machines).

Push a button and the Hele-Shaw Fluid Power Pump will start your machine on one or a complete cycle of automatically controlled operations. Push another button and it will stop or reverse. Convenience doesn't stop here. Changes in volume and direction of discharge can be made at the touch of a finger. The Hele-Shaw Pump can be located conveniently at any point on or off the driven machine.

There's pressure—all you need—up to 3000 pounds per square inch, mechanical simplicity, thorough dependability, and usually a saving in power when you drive with Fluid Power. Nothing to oil because the Hele-Shaw Pump is self-lubricating.

Still, we've only scratched the surface of Fluid Power's advantages. Why not look at *all* of them before you design, build or buy machinery. Our own men, experienced in solving design problems hydraulically, are eager to help you.

A Hydraulic Pipe Testing Machine, driven by a Hele-Shaw Pump, has been in operation 11 years at The Seamless Tube Plant of Spang-Chalfant & Co., Inc., Ambridge, Penna. Although frequently operated for 24 hours at a time repair costs have been at a minimum.

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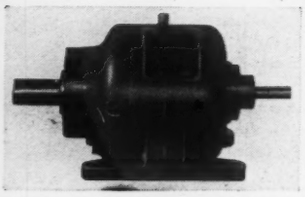

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Established 1901

Centralized Lubricators

(*Continued from Page* 49)

distribution of the oil is positive, the bearings may be at a higher or lower level than that of the pump unit.

Three main types of pump units are available:

1. Cyclic or high-pressure type driven from a rotating shaft of the machine by a gear or chain. The lubricating cycle, which may be adjusted from 5 minutes to 5 hours, is controlled by a positively driven cam, the contour of which determines the duration of, and interval between, the feeding periods. This type is particularly suitable for machines requiring close control of feed.

2. Continuous type driven from a rotating shaft or a reciprocating member of the machine. This type feeds oil to the bearings at a slow, continuous rate, which rate depends on the piston diameter, stroke and speed. Various standard sizes are available to meet a wide range of requirements as regards drive speed, feed rate, and reservoir capacity.

3. One-shot type hand-operated. This type is particularly adaptable to machines which require infrequent oiling, such as from twice a day to once a month, as in business machines. It is capable of being regulated to feed from 1 to 900 drops per operation and produces a normal line pressure of about 50 pounds per square inch.

Feeding Is Visible

Shown in *Fig.* 9 is a fully automatic centralized system, comprising a pump-reservoir unit driven from a rotating shaft of the machine, control valves at each bearing and a single-loop distribution line connecting the pump and control valves. The controls are individually adjustable at the bearings to feed as little as one drop in ten pulsations or as much as five drops per pulsation, their rate of feed being visible at all times through sight-feed glasses. As many as 100 controls may be operated from a single pump. The controls may be arranged in gangs with drip lines to groups of bearings, or individual valves may be located at each bearing served with the loop line leading through them, or on dead ends or branch lines, thus being flexible in connecting moving parts of the machine.

An indicating lever is provided at the pump. The lever rises and falls at each pulsation, which may be two per minute or less for systems requiring a slow rate of feed. Holding the indicating lever down causes all control valves to discharge oil rapidly to the bearings, as is desirable when starting up a cold machine. The number of pulsations per minute is governed by the style and model of the pump and its speed. Six styles and nine different models of pumps are manufactured, having a reservoir capacity of 1, 3, 4, and 16 quarts. Individual feeds as low as

(*Concluded on Page* 102)

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"LOGAN" Sure Flow Pumps are adaptable to an unusually wide range of service. They pump hot or cold liquids; and safely handle chips, filings, abrasives and most corrosive impurities. Model SFM 100, illustrated at right, is SELF PRIMING and can be mounted entirely away from the source of supply. No part of the pump need be submerged. No priming reservoir, foot valve or check valve is needed.

FLANGE MOUNTING for DIRECT INTAKE FROM SUPPLY TANK

Model SFM 300, illustrated at left, is designed for direct mounting on the side of the supply tank, or for installations when streamlining or lack of space prevent the use of an exposed intake line. Intake is direct through the flange base. The "LOGAN" Sure Flow Line is complete —10 sizes, 4 to 150 GPM . . . with power applications and mounting styles to fit every pumping job. Write for Catalog No. 60 showing complete line and specifications.

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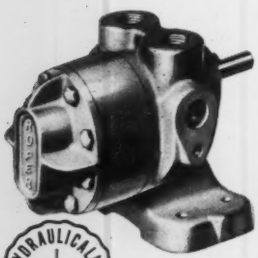

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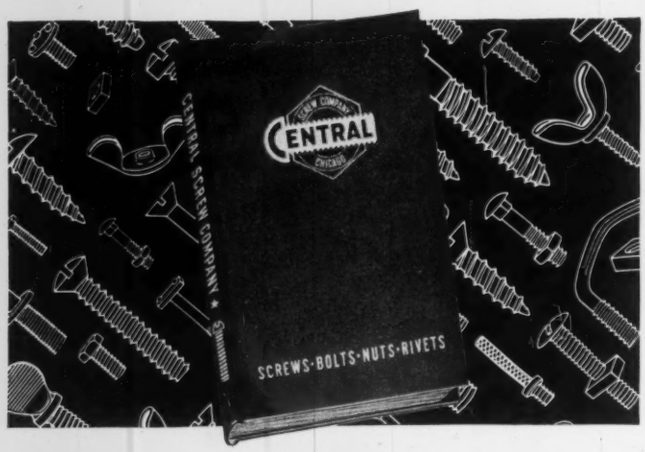

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(*Concluded from Page* 96)

one drop per hour or as high as ten drops per minute can be secured.

In *Fig.* 8 is a control valve of the system shown in *Fig.* 9. During circulation, the pressure is not sufficient to lift the spring-loaded needle valve from its seat, consequently the oil flows directly through the valve. *Fig.* 8 shows the position of the valve during pulsation pressure. By blocking the return flow of oil to the pump automatically at predetermined periods, the oil pressure is built up in the line sufficiently high to lift the spring-loaded needle valve from its seat. In consequence, the oil flows through the drilled passage and sight-feed glass to the bearing. *Fig.* 3 shows an automatic screw machine equipped with this system.

Utilizes Two Lines

In *Fig.* 1 is shown the design of another type of control valve suitable for handling grease. This control is designed for a so-called dual line system. Two distributing lines are used to connect the central pump unit with the controls and the lubricant flows alternately first through one line, then the other. The central pump unit includes a double-plunger pump, four-way hydraulic reversing valve, speed reducer, adjustable accumulator, and a suitable reservoir. Pressure applied alternately to first one of the dual lines and then to the other causes the control valves connected to them to discharge a measured amount of grease to each bearing and, at the same time, recharge controls for the next operation. The four-way reversing valve at the pump delivers grease from the pump alternately to the dual lines. An adjustable pressure control valve can be set for virtually any desired pressure.

Frequency of operation of this pump is hydraulically controlled. The system can be electrically controlled, but the hydraulic method is generally preferred because of its simplicity. The accumulator is adjustable and acts as a simple expansion chamber to receive a predetermined amount of grease each cycle of operation, before pressure can be built up in the line to discharge all control valves. *Fig.* 11 shows the installation of another design of a fully automatic centralized system on a roughing mill and roll stand of a continuous strip mill.

Although centralized lubricating systems do not permit the re-use of lubricants as do splash, bath and circulation oiling they may be satisfactorily applied in locations where other systems are uneconomical or otherwise not desirable.

Recently completed, a proposed "American Standard for Specification and Horsepower Ratings of Vegetable-Tanned Flat Leather Belting" has been drawn up by a joint committee organized under the procedure of the American Standards association. American Society of Mechanical Engineers is sponsor, with the engineering committee of the American Leather Belting Association as collaborator.

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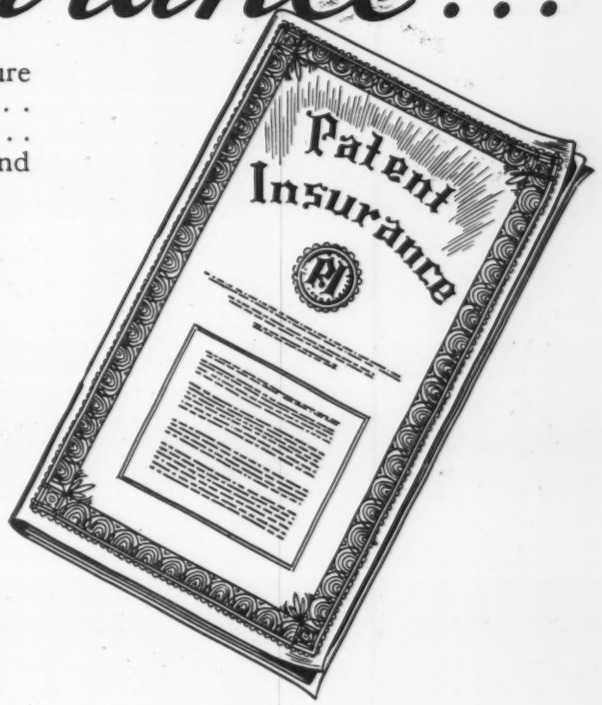
Security from loss due to improperly protected engineering developments depends upon the inventor's initiative. The United States Patent Office provides iron-clad protection, but utilization of this service involves many highly technical factors.

Proper use of the U. S. Patent Office facilities is fully covered in "Inventions and Their Protection" . . . an authentic book written expressly for engineers and technical men . . . men who are constantly using or developing patentable ideas.



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INVENTIONS AND THEIR PROTECTION; by George V. Woodling, E. E., L. L. B.,; 316 pages; 16 chapters; 47 illustrations; 223 topical headings; 6x9 inches; bound in blue clothboard; $5.00 (Postage prepaid on orders accompanied by remittance in full). Orders for delivery in Ohio must be accompanied by 15 cents additional to cover compulsory state sales tax.

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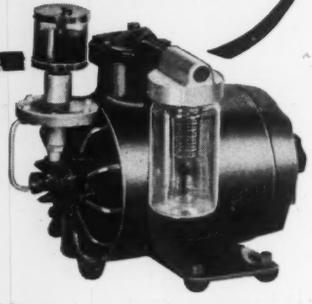

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New Hair Dryer Is Silent Salesman

(*Concluded from Page* 42)

shown in *Fig.* 2 to accommodate the motor brush holders. Easy access to the brushes is attained by the use of removable fiber plugs.

Transmission of vibration from the pump and compressor assembly to the helmet is minimized by the use of a special rubber tubular connector in the air duct.

Air is distributed in the helmet in jets, the orifices being placed in flexible conduits. Between the conduits, spaces are provided in which the air is turbulent and the exhaust delayed so that a full quota of moisture is absorbed. These features may be seen in *Fig.* 3.

Exhaust ports, illustrated in *Fig.* 3, are provided at the top of the helmet thus directing the hot, moist air stream away from the customer.

Suspension bracket, shown in *Fig.* 2 enables the helmet of the dryer to be rotated on its standard through 160 degrees. Two legs of this bracket travel vertically in rigid guide rails. The third provides the means for attachment of the tapes of the spring balances which sustain, and provide for the vertical attachment of the helmet. The balances are mounted on a plate which also forms a base for the guide rails. These rails are kept in alignment by a ring at the lower end.

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By passing the air stream from the fan over the motor which has an open frame with an annular deflecting ring, cool motor operation with an exceptionally long brush life is obtained. About 225 watts of motor heat loss is absorbed, reducing by that amount the heat that must be supplied by the heating elements which are shown in *Fig.* 3.

Ease of control of the air temperature is provided by the rotary switch on the front of the helmet as shown in *Figs.* 1 and 3.

Quiet operation of the entire unit was enhanced by means of a combined cellulose and felt lining of the cabinet and a felt lining in the supporting tube as well as by providing an annular air inlet around the cabinet in which the air travels inward at a speed sufficient to cancel the motor and fan noise inside the cabinet.

As a protection against the action of chemical solutions which might come in contact with the dryer, the enamel finish is given a coat of Polymerin and all bright parts are either stainless steel or chrome plated.

The attractiveness of the general design is the result of the work of Egmont Arens, industrial designer, who was called in at an early stage of the development so that an orderly procedure of co-operation would eliminate any wasted effort, time and money.

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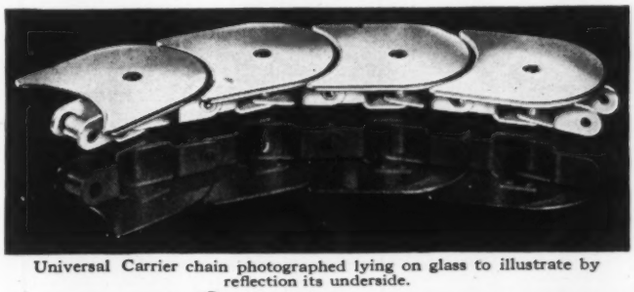

Universal Carrier chain photographed lying on glass to illustrate by reflection its underside.

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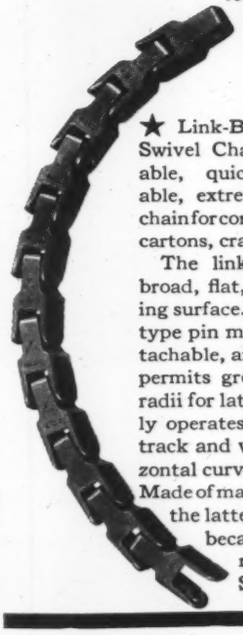
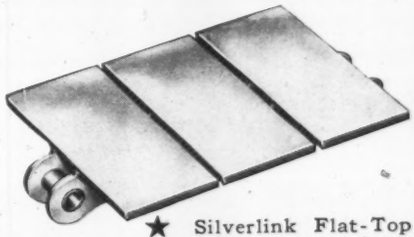


★ Link-Belt No. 4250 Swivel Chain is a durable, quickly detachable, extremely flexible chain for conveying cases, cartons, crates and cans.

The links provide a broad, flat, clean carrying surface. The cast ball and socket type pin makes the chain easily detachable, and the joint construction permits great flexibility and short radii for lateral curves. Chain usually operates in standard 2″ channel track and will operate around horizontal curves as small as 12″ radius. Made of malleable iron or PROMAL, the latter being usually preferred because of its longer life and resistance to corrosion. Send for Folder MD 1637.



★ Silverlink Flat-Top Conveyor Chain is used for handling bottles, jars and cans through cleaning, filling and capping operations. For this service, the chain articulates freely and prevents "humping." Its light weight results in minimum power requirements and wear, and permits the return-run to hang unsupported without requiring excessive structural strength. Metal specifications may be selected for resistance to acid action or corrosion, and to withstand thorough cleaning during and after the day's run. Send for Folder MD 1637.

★ Link-Belt Crescent Conveyor Chain with attachments is cast or formed from ferrous or non-ferrous material, to make a continuous conveyor for handling bottles or other containers in a rectangular, circular, semi-circular or snake-like path. A conveyor employing this chain presents a practically unbroken surface, even at the turns. The bottoms of the attachments present good sliding surfaces for supporting guides.

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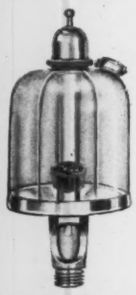

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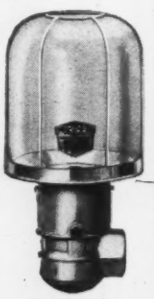

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(*Concluded from Page* 53)

Test results are based on coupons cast either integrally or poured separately at the time the casting was made. Engineers will recognize that while test coupons reflect the properties of the materials used, the results are not necessarily indicative of the strength of the casting. The effect of mass, design features, and changes in section may modify, to an important degree, the mechanical properties that will be developed in a casting. To aid in interpreting the test results, general properties and typical applications of the several types of cast steel are given under "Remarks."

Metallurgical Factors Affect Values

It will be recognized, of course, that the properties shown in these tables are typical properties; they are not the values to be used in setting up minimum specifications. Factors like grain size, variations in chemistry and heat treating practice are only a few of the variables that will tend to modify the mechanical properties of steel and cast iron. These data are most effectively used as a guide rather than as absolute values.

In order to complete the picture of molybdenum alloys in machines, a partial list of molybdenum alloy irons and their recognized engineering applications are included in TABLE III. Properties indicated may be thought of as reflecting results obtained in standard size test bars produced commercially. As in cast steels, values shown indicate the mechanical properties of the material itself rather than the finished casting. The experienced engineer has, of course, learned to make the adjustments that are necessary to correlate such engineering data with actual applications.

Factors Influencing Power Loss in Bearings

(*Continued from Page* 57)

words a straight-line curve on log-log paper was obtained for f versus ZN/p at each value of unit pressure.

Later, when the total flow of oil to the bearings was varied, it was found that for each value of pressure the coefficient of friction varied exponentially with ZNQ/p. The resulting values of f were then plotted against ZNQ/p for various values of p as shown in *Figs.* 4 and 5. It was also found that a cross-plot of f versus p at constant values of ZNQ/p gave a straight-line curve on log-log paper. Thus, we are led to believe that $f = \phi_1(ZNQ/p,p)$ for a given bearing when l/d and d are constant, as illustrated in *Figs.* 4 and 5.

The values of specific heat, absolute viscosity and specific gravity are shown in *Fig.* 6 for the oil used in these tests. (The viscosity curve for this oil is substantially the same as that for the oil used in the work

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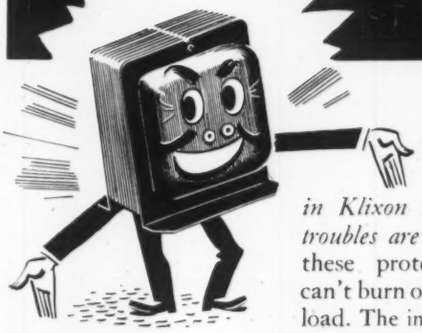

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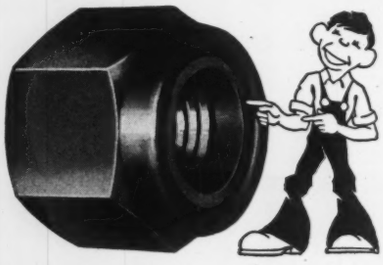

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on the effect of surface finish.)

In order to determine the relationship of f and ZNQ/p for the bearings of various size, curves at constant pressures of 150 and 600 pounds per square inch were drawn as shown in *Figs.* 7 and 8. Hershey has shown by means of dimensional analysis that $f = \phi_2(ZN/p, c/d, l/d)$ and $x/c = \phi_3(ZN/p, c/d, l/d)$ thus removing the requirement for geometrical similarity so far as the clearance-diameter and length-diameter ratios are concerned. The tests herein reported also indicate that in addition $f = \phi_4(ld)$ when l/d is constant.

This relationship is illustrated in *Figs.* 7 and 8, in which a family of f versus ZNQ/p curves, drawn at constant values of p, give straight lines on log-log paper with ld as the parameter. The curves are drawn parallel to each other in order to simplify the mathematical derivation of the power-loss formula. Some slight shifting of the actual test curves was necessary to make them parallel.

Power Loss Formula Derived

In order to demonstrate the inter-relationship of the primary variables affecting the power loss in bearings, Equation 6 was derived from the test data. The formula is entirely empirical and it should be noted is based on data which have been made consistent within itself. An analysis of the derivation follows:

Referring to *Fig.* 9, log f, plotted against log ZNQ/p at constant pressure, gives a series of straight-line curves with the bearing size ld as a parameter. These straight lines may be expressed mathematically by an expression of the form:

$$\log f = \log f_\circ + m \log ZNQ/p \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where

$f_\circ$ = function of p and ld
m = function of p

Now

$$\log f_\circ = \log f'_\circ + m' \log (ld) \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where

$f'_\circ$ = function of p
m' = function of p

Hence

$$\log f = \log f'_\circ + m' \log (ld) + m \log ZNQ/p$$
$$\log f = \log [f'_\circ (ld)^{m'} (ZNQ/p)^m]$$

or

$$f = f'_\circ (ld)^{m'} (ZNQ/p)^m \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

From the definition of the coefficient of friction

$$L = (.746/12 \times 33{,}000)\, \pi\, dNWf = .00000592\, pNd$$
$$(ld)\, f \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Substituting Equation 4 in Equation (3)

$$L = .00000592\, p^{1-m} f'_\circ\, l^{1+m'} d^{2+m'} N^{1+m} Z^m Q^m \quad \ldots (5)$$

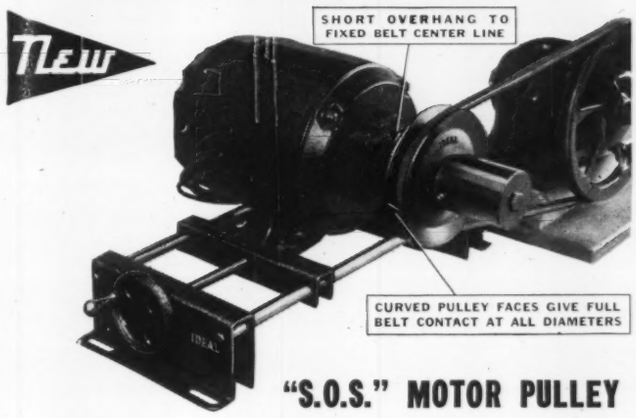
From the master curves of which *Figs.* 7 and 8 are examples at 150 and 600 pounds per square inch, respectively, the values of $f'_\circ$ and the slopes m and m' may be determined. Choosing p equal to 150 pounds per square inch and substituting the values of $f'_\circ$ and m and m' in Equation 5 gives the power loss equation:

$$L = 2.81 \times 10^{-3}\, d^{1.55}\, l^{.55}\, (N/1000)^{1.43}\, Z^{.43}\, Q^{.43} \quad \ldots\ldots (6)$$

As derived, Equation (6) applies strictly to 150 pounds per square inch bearing pressure. For other values of pressure, a slight change occurs in the value of constant and exponents.

Typical curves of speed versus loss, *Fig.* 10, and bear-

VARIABLE SPEED



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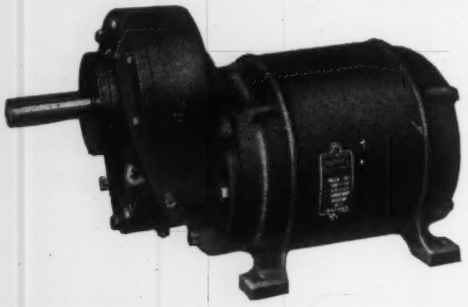

This helical gear speed reducer, one of 19 styles, is especially well adapted for driving thread millers, gear hobbers, punch presses, shears, keyseaters, planers, etc.

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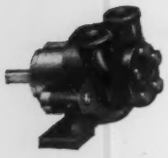

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ing length versus loss, *Fig.* 11, have been plotted by use of this formula. Curves illustrating the effect of other variables on loss can be plotted.

Addition of a groove over the top half of a journal bearing reduces the loss somewhat, but the size of the groove used has little effect on the value of the loss. Width of the groove was varied from 1/5 to 2/3 of the bearing length. The effect on the power loss was not measurable in these tests, the reasons for this being that a vacuum occurs over a large portion of the upper half.

Machine Fastenings in Design

(*Concluded from Page* 41)

locking action has the advantage of providing a larger contact area. TABLE III shows a comparison between the engaged thread area and the face area of standard nuts from ¼ to ¾-inch size. Thus, vibration of the held parts which tends to effect looseness of an assembly has less effect because of the locking friction between the screw threads. *Fig.* 12 shows a sectional view of an internal combustion engine wherein these lock washers have many applications.

Another type of spring washer applicable to unusually severe service is shown in *Fig.* 13. The arched shape affects higher tension in the bolt (and hence more load on the threads) than the helical type but

TABLE III

Nut Bearing Areas

Nut and Threads Per Inch	Nut Face Area Sq. In.	Area of Threads in Contact Sq. In.
¼ x 28	.1012	.1153
5/16 x 24	.1197	.1365
3/8 x 24	.1380	.2015
7/16 x 20	.1565	.3106
½ x 20	.2454	.4180
9/16 x 18	.3528	.5819
5/8 x 18	.3835	.7602
¾ x 16	.4448	1.107

this load falls off more rapidly should clearance develop between the head and the work. TABLE IV gives the tension loads exerted on ¼-inch 28-thread screws for various amounts of back turn of the nut for both the helical and arched type washers. Because of its two points of application of thrust against the screw head, the arched type washer produces pure tension in the screw.

MACHINE DESIGN gratefully acknowledges the contributions of the following companies to this article: Crane Co., TABLE II; Eaton Mfg. Co., TABLE III, *Figs.* 12 and 13; Lamson & Sessions Co., TABLE I; Parker-Kalon Corp., *Figs.* 7, 8 and 10; Shakeproof Lock Washer Co., *Figs.* 9 and 11.

An outstanding case study of the effect of the armament program on industry is provided by General Motors Corp. which has undertaken contracts in the amount of $410,400,000 for defense materials for the United States, Britain and Canada. The extent to which the corporation's facilities are being extended must be evident when it is noted that in the largest previous year in its history, 1937, total business amounted to $1,606,000,000.

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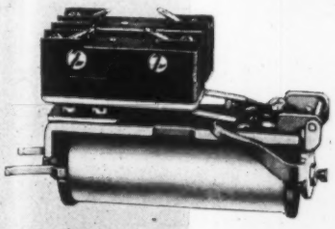

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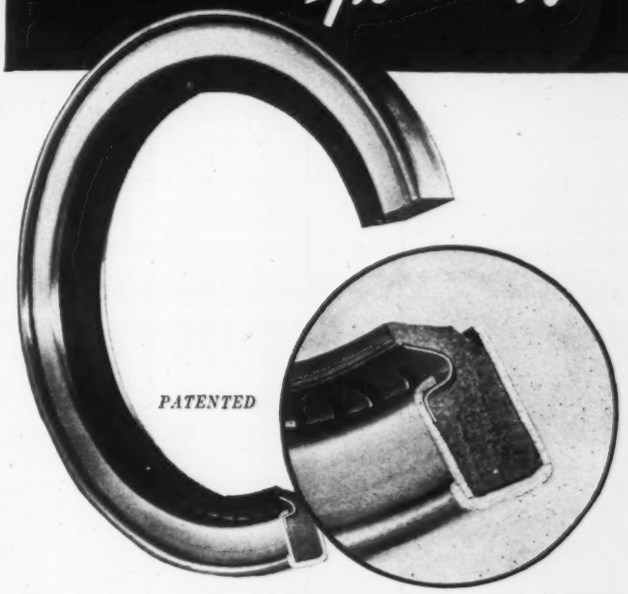
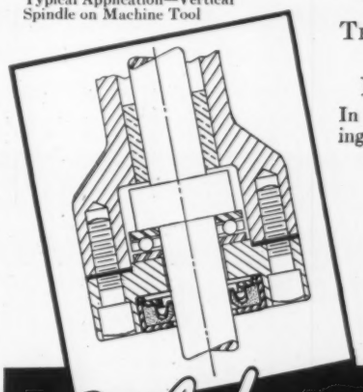
THIS OIL SEAL STANDS UP
—Does not get Soft and Flabby!



You have seen them—fighters, who seemed to have everything. But often—when the going really gets tough—you have watched them fold up, go soft. That's the way with oil seals which become soft and flabby in service. Not so with the Garlock KLOZURE Oil Seal! Made of an exclusive compound, the sealing ring of the Garlock KLOZURE *stays firm—stands up* even under the most severe conditions.

Typical Application—Vertical Spindle on Machine Tool



THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK
In Canada: The Garlock Packing Company of Canada Ltd., Montreal, Que.

Garlock KLOZURE